GULICK HYGIENE SERIES

THE BODY AND ITS DEFENSES

BY FRANCES GULICK JEWETT

THE GULICK HYGIENE SERIES

EDITED BY

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THE
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CONTENTS

INTRODUCTION

In the following pages emphasis is laid on function rather than on structure, on bodily health rather than on the mere mechanical operation of bone, muscle, gland, and tissue. So much of structure is, however, included as is necessary to show that we are personally responsible for the kind of service which we receive from the organs of the body; and that we are equally responsible for the habits of bone and muscle which determine the physical representation of ourselves to others.

Attention is drawn to right and wrong habits of sitting, of standing, and of walking; to the relation of the school desk to spinal curvature; to laws of growth, through the knowledge of which correct habits of posture may be secured; to the value of physical exercise as an aid to general health; to the development of muscular vigor and to the renewal of tissue through food and exercise.

By natural transition the work of the muscles leads to a study of the source of their energy, — the blood. Simple tests, easily applied, acquaint the reader with the cause of rapid and slow heart beat, with methods of training the heart to increased power, with reasons

why an untrained heart should not be overtaxed, with the work of the lymphatics and the nature of the exchanges made between lymph and plasma. The insidious effects of alcohol on the heart and on the entire circulatory system are emphasized.

Certain conditions of breathlessness are discussed, and reasons are given for the statement that a man runs as much with his heart and with his lungs as with his legs. In natural sequence, this explanation involves not merely the structure and the function of the lungs, but also a study of the exchange of gases both in the tissues and in the air sacs.

The notable experiments of Professor Chittenden with United States soldiers in New Haven, and of Dr. Cannon with cats in the Harvard Medical School, necessarily add a touch of picturesque reality to the otherwise prosaic subject of digestion. Through this introduction to the subject prominence is given to the change of food from solid to liquid form, and to its absorption by the villi; also to the food requirements of the body under differing conditions of age and activity; to the value of bulk in the food supply; to the functions of the liver and of the kidneys, and to the influence of alcohol in undermining their power for work; to the relation of sweat glands to bodily heat, and to the interdependence of work, heat, and fuel in the operations of the body.

In close connection with the physiology of the text, several chapters discuss communicable disease and its prevention. They study tuberculosis, its cause, how to avoid it, and how to cure it; also typhoid fever as related to pure water and clean milk; dangers from the common drinking cup and the common towel, from the fly, the mosquito, and unsanitary surroundings; also the cause of specific epidemics and ways of escape from them through vaccination, antitoxin, cleanliness, and general physical vigor.

The closing chapters of the book are devoted to the nervous system, to its structure and its function, to methods of governing it through mental processes, and to the training of the senses.

These and other related topics have been brought to the notice of the students of this volume with the hope of imparting such enthusiasm for personal health, and such clear notions of how to secure it, that the bodies of growing children may be strengthened as well as straightened, that lives may thereby be lengthened, and that through increased physical well-being the sum of human happiness may itself be increased.

Not merely is it the purpose of this series to teach scientific facts, but also, and especially, so to arrange and present these facts that from page to page they shall hold the reader's close attention and inspire personal loyalty to the laws of health. To further this purpose

side headings have intentionally been omitted, so that each chapter may make its first appeal to the reader as a unified whole rather than as a series of disjointed fragments. While the disadvantages of side headings in interrupting the continuity of thought have been avoided, all their advantages are secured through the questions at the end of the volume, which, in a better form, answer the same purpose.

In so far as possible, the instruction of this text-book is everywhere reënforced by illustrations. Special mention should be made of indebtedness to the *American Journal of Physiology* for illustrations used by Dr. Cannon in his article on "The Movements of the Stomach studied by Means of the Röntgen Rays" (1898), and to Professor Chittenden for photographs of the soldiers with whom he carried on his food experiments.

Other valuable illustrations have been reproduced from *Practical Hygiene* by Alice Ravenhill, from *The Human Mechanism* by Theodore Hough and W. T. Sedgwick, from *Alcohol and the Human Body* by Sir Victor Horsley and Mary D. Sturge, and from *Unser Körper* by F. A. Schmidt. To each of these and to many other important works this little book is indebted not merely for illustrations but also for valuable facts which have been used in the preparation of its subject-matter.

F. G. J.

THE BODY AND ITS DEFENSES

CHAPTER I

BONE AND MUSCLE RECORDS

Many cases are on record where a man has tried to hide his face when he thought his photograph was to be taken. He has seemed to understand that the photograph might betray him some day and lead to his being arrested again.

But some of our largest cities have adopted a new and surer way of keeping a reminder of their captured men. They measure each man carefully in different directions, — height in standing and in sitting, distance from the outstretched finger tip of one hand to the outstretched finger tip of the other, length and width of head and face and right ear, length of left foot, of left middle finger, and of left forearm. Scars are noticed and recorded; also the color of the hair and eyes, the shape of the nose, the number of teeth, etc.

In addition, the photograph is taken. And, queer though it may seem, the photograph is less important than the measurements in identifying a man if he is

ever arrested again and brought to the police station. The reason is that our bone measurements change little after we are twenty-two years old. Ever after that the size of face and head, the length of arms, of fingers, and of legs are all as they will continue to be until we die.

TAKING THE LENGTH AND THE WIDTH OF HIS HEAD

A caliper compass is used

This, then, is a sure and sensible way of keeping the record of a man. When a criminal arrives at the police court, no matter how violently he declares that he has never been there before and that this is his first offense, the officers measure him at once and also search their written records. If they find there any set of measurements which is a duplicate of those just taken, all the man's denials are in vain. Those officers know that never yet have two people been found who had precisely the same dimensions for all the bones which were measured.

It takes but ten minutes for the officers to get their record of a man — photograph and all. But it took the

man himself twenty-two years of life to make that body which is now his physical record of himself.

As a rule the body of a baby is very perfect; but even in its cradle and before it can walk a step or speak a word it begins to receive daily training of muscles and bones, of eyes and hands and brain. During these early months also older persons feel great responsibility for the child.

SEATED TO BE MEASURED

With his back against the upright scale they measure the height of his trunk

Notice any nurse or careful mother with the baby in her arms. See her hold a firm hand against the back of the head as she supports the backbone and holds the child up for a look at the world. She knows, as the doctor does, that for months there is more cartilage than bone in the supports of that small body, and that, while bones are in this condition, they cannot be trusted to do independent work.

Certain Indians have known this for centuries. A famous tribe that admired flat-headed men used to secure these heads for their boys by a clever contrivance.

They simply fastened a board by a hinge to the head of the cradle and allowed it to press down upon the forehead of the baby whenever he was strapped in place. As months passed the small skull not only continued to grow but also set itself hard and firm in the desired shape. And once firmly set there was never any hope that the grown Indian could restore his head to the perfect shape which it had when he was born.

THE MIDDLE FINGER IS MEASURED BY A CALIPER COMPASS

Thus some of our bones and muscles are trained by other people before we are old enough to make decisions for ourselves. Yet, whoever is responsible for results, two laws of bone growth should never be forgotten:

1. Many bones can be compelled to take a bend in this direction or that while the child is growing.

2. Almost no bone can be forced to make a new bend after it is twenty years old.

But there is other training which is more complex and for which we ourselves are responsible.

On a certain day two boys entered the same shop and asked for work. The first boy was refused, the second was accepted, and the explanation lay with the

bones and the muscles, which had made different records for the two bodies to which they belonged. The first boy walked with a shuffle and had a slouching body. Before he had spoken a word the business man who met him was unfavorably impressed and ready to reject him.

CHINOOK BABY IN HIS CRADLE

The weight on his forehead will help turn him into a flat-headed Indian

The second boy walked as if he respected his body thoroughly. His head was erect, his shoulders well squared, and each muscle gave the impression that he was in the habit of doing things with energy. This boy was accepted as promptly as the first was refused.

Imagine a man who needs the help of other men in carrying on some undertaking. Then try to picture the sort of body that will serve him best. Think how his success or his failure will be influenced by bone and muscle, by the way he stands and walks, by the way he uses his back and arms and legs and feet.

Let two women enter a store or a schoolroom, a theater or a church. Which will be served most quickly,

she who shuffles as she walks, has crooked shoulders and a head thrust forward, or the woman who steps forward gracefully, who walks as if her body were her best possession, as if it were her true representative? Surely the second woman is queen wherever she goes. Without question, at every stage of growth the body proclaims the story of what has happened to it and of all that it has done with itself since it began to live.

The point of this chapter, then, is not that police measurements of size and shape make very much difference to us, but that it is more or less within our own power, while we are growing, to make the records which are to represent us the rest of our lives.

If a man by his own acts or his own carelessness must live miserably in a shanty when he might have lived gloriously in a palace, we are apt to blame him more than we pity him.

CHAPTER II

DANGER FROM THE SCHOOL DESK

For the sake of making discoveries about yourself, stand before a mirror and study the outline of your back, your chest, your shoulders, and your legs. Try to stand precisely as you do every day at home and at school, so that you may get a correct notion of the records your bones and muscles have made for you thus far in life.

HE STANDS CORRECTLY

(Copied from *Practical Hygiene*, by Alice Ravenhill)

Let your eyes be keenly critical. Are you standing squarely on both feet? Are your knees bent or straight? Is your back erect enough to hold your head up where it belongs, or does your head droop forward so that your chin sticks out too far in front? Are your shoulders on a level with each other, or is one higher than the other? Is your chest rounded out like that of a soldier, or is it flat and curved in like a scoop between the shoulders? Rub your hand across your back to

see whether or not a corner of a shoulder blade reaches out like a young wing starting from the wrong place.

If you can give creditable answers to these questions, your future course is easy. Simply keep on growing as you have begun, and when your bones are hard you will have the shape you wish. If, on the other hand, you are not perfectly satisfied with what you find, rectify each item of your posture separately, while you still look at yourself in the mirror.

HE LESSENS HIS LUNG CAPACITY

(Copied from *Practical Hygiene*, by Alice Ravenhill)

Stand as nearly as you can as follows: both feet on the floor, each bearing its own share of weight; both knees stiff; both shoulders square and on a level with each other. Draw in your chin until the back of your neck would touch a stand-up collar if you had one on. Inhale a breath so full and deep that your chest looks like that of a drum major ready for his regimentals. Now your back has its correct shape for standing. It should be slightly curved in its stretch from neck downwards.

Later in the day test yourself again. You are now seated. Perhaps you are in the schoolroom. If you have time for it, take different positions and note the

feelings in connection with each. First, sit with feet squarely on the floor, back straight, head erect, and chest raised. Are you comfortable? Can you draw a full, deep breath? Test this thoroughly.

Now slip down in your seat, curve your head forward, let your back be bent, let your chest fall in, and once more try to take a full, deep breath. Notice that here in the schoolroom, where your brain needs oxygen for its work, you have reduced your supply by the way in which you have doubled up your lungs.

HE CURVES HIS BACK AND CROWDS HIS LUNGS
(Copied from *Practical Hygiene*, by Alice Ravenhill)

For the sake of variety take another position. Sit with one elbow on the desk, or with one foot drawn up under you, or with some bend at the waist line that will give a twist to the spine near the hip. The objection to taking any one of these as the usual position is that gradually the relation of the bones to each other will be so altered as to give the body an undesirable shape. In no wise does it harm any of us to twist this

way and that, to bend as far as we can in one direction or another. Indeed, all such exercise is most wholesome, provided no one position is taken often enough, or held long enough, to become a habit.

Curved Back and Hollow Chest

(Copied from *Practical Hygiene*, by Alice Ravenhill)

Sidewise twists which have become permanent are receiving much attention from doctors and school examiners to-day. These men claim that although the large majority of the curves are very slight, and although most of them will, in all probability, never become serious, still it is not safe to allow a curve either to form or to increase after it is formed, because we cannot tell what the outcome may be.

Dr. F. A. Schmidt, a scientific writer in Germany, says that Dr. W. Mayer examined the backs of three hundred and thirty-six girls and found that one hundred and eighty-nine of the number had what is called lateral curvature of the spine. He found that girls between seven and thirteen years of age had much more trouble than

those who were under seven, and he concluded that the habits of sitting formed at the school desk explained the difference, because the older children had spent more hours, days, and years in the schoolroom than those who were younger.

Another German investigator found that in a certain group of children eighteen per cent of the boys and forty-one per cent of the girls had these same curved spines. This looks as if the girls of that group had been more careless than the boys in the way they sat at their desks. Or it may be that the boys had saved themselves by taking more exercise out of the schoolroom.

HE TWISTS HIS BACK

If he takes the same position day after day, some of the vertebræ will finally become wedge-shaped. Habits of the school desk may thus change his shape for life

(After Schmidt)

Follow for yourself the work of muscle and bone, and understand what happens when a child gets into the habit of sitting at his desk with elbow up on one side, shoulder lifted, and body half screwed round. Notice that

if you tip up one hip the spine curves sidewise as a balance. If you raise one shoulder it pulls the spine accordingly. Evidently each separate movement of the muscles of the back brings its result in the curves of the spine, and the same curves, repeated day after day at the same desk, hold the bones and the cartilage which lies between them in wrong positions, until they are as truly pressed into a new shape as if the change were planned for.

CURVED BY THE WAY HE IS HELD

If his nurse will carry him as often on one arm as on the other, no harm will be done to the vertebræ

So far as health is concerned, the main objection to these lateral curves is that if they are allowed to go on and become serious, they will interfere with the successful work of the large organs of the body. Then, too, when a curve becomes permanent — although it may be small — the nerves themselves are often affected by it, and the body suffers at the point which is supplied by these nerves. A person enduring this pain may not know its cause, but his ignorance will not save him from suffering.

But prevention is best of all. Children may save themselves by being careful to balance the exercises which they allow the muscles of their backs to take. All that is

needed is a little knowledge and a firm purpose. Whoever allows himself to be shaped by undesirable habits of muscle and bone will have cause for keen regret in later years. But he who, in his youth, controls his habits and shapes his body with care, will never regret it. Four rules will help:

NOTICE HIS SHOULDERS

If this position becomes a habit, the boy will have a crooked body when he is a man

1. Do not sit day after day in the same twisted position. When you have been seated in one way for a while, then change and sit in some other way.

2. Do not carry a heavy weight of books on the same arm back and forth from school every day. Carry as few books as possible on either arm, and let each arm do its share of the work.

3. Do not carry a baby brother or sister on the same hip every day. The weight just there will tend to give a wrong twist both to your back and to his.

4. If you must stand for hours at a stretch, learn to rest one leg by using the other. Don't let one side sag down from habit. Change sides.

CHAPTER III

MUSCLES CONTRACTING AND STRETCHING

The coal heaver round the corner has a superb set of muscles over the working part of his back. They are so well developed that, as he stands bent over his work, it is evident that these muscles give him a back of tremendous strength. By their help he shovels coal for hours at a time through the days and the weeks of the year. Moreover, when he has finished his day's work he does not seem overtired. He is still ready for his joke and his laugh with his children at home. He even jokes at the expense of his own back, for although it is so well developed and so tireless, still the man himself frankly acknowledges that it is sadly bent, and that by no effort on his part can he stand straight or walk as would please him best. He says that that is the price he has had to pay for the

BENT BY HIS WORK

kind of work he has chosen as a life occupation. More people have round shoulders developed in some such way than are troubled with any kind of lateral curvature of the spine.

A bicycle rider whom I know has a back quite as bent, although from a different cause. It is muscular, strong and efficient, but it never looks well except when he is working his legs fast on his wheel. It is bent from the position it has been allowed to take, rather than from the work it has done in that position.

BENT BY BICYCLING

Something must be wrong, however, and we wonder what it is. Here are these men and multitudes of others whose backs are splendidly developed, but who are so bent as to look almost deformed. For years no one could entirely explain the cause of the combination—the strong but bent back. At last, however, close observation and logical reasoning have made the case clear. I give the explanation in the fewest words possible. The value of this explanation will be measured for us by the use we make of the law:

Muscles stay in the position in which they do their heaviest work.

A man of my acquaintance who travels a good deal, says that when, for a few weeks, he carries his suit case persistently with the same hand, that shoulder becomes an inch or an inch and a half lower than the other, while, at the same time it becomes stronger. This shows how a muscle can be lengthened even while it is being strengthened.

Stretch a muscle out and work it hard, as a coal heaver does when he curves his back over for the shoveling and the lifting of the coal, and those muscles, being obliged to work hard, even while they are stretched, will gain their strength in that position and will stay elongated even when they are not at work. Let their size and their strength increase while they are stretched and you have given them their permanent shape.

Two oarsmen illustrate this law in opposite ways. One does all his hardest rowing with a straight back, the other with a back that is curved. Their work continues day after day until each back is as strong and as muscular as the other. But see what the results are. One man walks as if he had spent his boyhood curved over a school desk without a thought about what might be happening to his spine. The other man looks as if he might have spent those same years at West Point with officers and fellow-students who compelled him to stand

straight whether he wished to or not. Yet the boyhood of the two men may have been the same. Indeed, the difference just now lies entirely with the two positions in which they did their rowing. Their muscles, when they walk, simply betray some facts about their recent history.

BENT BY AGE

Look at the hand of a piano player,—it is open because he always exercises it hard in that position; and the hand of the oarsman,—see how his fingers curl up as if they were ready to grasp his oar even when it is not in sight. An oarsman's hand tells the story about his occupation.

From the man who digs to earn his daily bread on the farm or in the coal mine, to the man who climbs a mast and risks his life in the tempest,—through each occupation of life the muscles of the body are called upon to do their hardest work in special positions. And it sometimes seems as if numberless human beings would have to submit to their fate and accept muscles which their work has forced on them; for after a man has chosen his life work he cannot leave it simply because he objects to the shape which it is giving to his body.

Fortunately, however, there is a happy outlook even for such people as are obliged to work with their backs bent, for there is another important fact about this law of contracting and stretching. I give it concisely:

Brief, vigorous exercise in the right position will undo much of the harm of long-continued exercise in the wrong position.

If a man who works in a bent posture all day will spend five minutes a day in taking vigorous exercise with his back straight, alternately tightening hard and then relaxing the muscles of his back and neck, he will find that, within one month, there will be an improvement. By this simple device a man may save himself from his rounded back and be able to hold his head where it should be.

Let the oarsman who objects to hands that curve like stiffened claws spend several minutes each day in first extending his fingers forcibly, then in relaxing them, and he will be sure to see results.

From these facts we learn that by the vigorous exercise of one set of muscles for a few minutes each day, we may be able to overcome the harm which is done by the long-continued plodding work of another group of muscles.

It often happens that the muscles of the chest become thin and flabby for lack of exercise, even while the back has become very strong. But these muscles may

be saved. Throw the shoulders well back and exercise chest muscles hard in this position. Exercise them while they are thus stretched and they will grow large and prominent in spite of what the man's occupation may be.

In this work of changing the shape and the power of a muscle the greatest strain must be put on the last third or the last quarter of the contraction which it makes. Remember that each muscle is inclined to stay in the shape which it takes when it does its hardest work; in other words, the law of the body is that doing a thing makes the body shape itself to that act.

CHAPTER IV

THE MUSCLE ITSELF

The audience was greatly interested, for the doctor who gave the lecture had just said that, with very little trouble, each man present could increase the size of his arm three quarters of an inch within one month, and could increase his chest measure an inch and a half during the same length of time. Those who listened were business men, and they were specially pleased with the part of the lecture which told them how they might set to work to secure this astonishing growth for themselves.

EXERCISE FOR THE BICEPS

To show what he meant, the lecturer asked his friend, a medical student, to illustrate the points one by one as he himself explained them. The student was well-knit and well-built. No unnecessary fat concealed the shape of his muscles, and he was ready to show the other

men what they also might do in behalf of their own development.

For a while it sounded as if the whole talk were to be a lecture on the size and shape of different muscles; for the doctor asked his friend to show his muscles one after the other in quick succession. "Now," said he, "show us the effect on the biceps of rotating the arm; the forearm; now the leg,—the big muscles; show that tensor. Now again will you go through four or five exercises that bring into play in succession first one arm, then the other, and so on?"

WELL-DEVELOPED MUSCLES

The student acted on the suggestions as fast as they were given. His smooth back and arms gave no sign of separate muscles while he stood quietly waiting to be told what to do. But as soon as he followed directions and used arm, leg, back, or shoulders, there sprang into view a succession of splendid muscles that seemed to have been lying in ambush under the skin.

In all this the student held no apparatus, but he used arms and legs as if he were pulling against some invisible weight. He was, in fact, pulling against the force of his own other muscles,—antagonistic muscles they are called. Try this for yourself with your forearm or with

your back. Decide to bring out one muscle and see how many others are called into action.

The lecturer then explained that muscles can be developed in this way with no apparatus whatever. He said that the power lies in making certain muscles pull against their antagonistic muscles. As he gave his directions he added that muscles must pull as hard as possible for a few seconds at a time, must then let go completely, then pull again for a few seconds, and so keep up the alternation for five minutes in the morning, for five minutes at night, and for ten minutes a day between times. Men who proposed to develop arm or chest could, he said, put in the extra ten minutes whenever convenient.

EXERCISE WITHOUT APPARATUS

It seems that the different pulls do not need to be in close succession, but may be slipped in anywhere during the day. The whole process of developing a particular muscle or set of muscles may thus be carried on without apparatus, without gymnastics, without fuss or feathers or display in any direction. The student testified that what he had done for himself in this way had increased the size of his own arm an inch within a single month.

As for securing really big muscles, however, anything enormous is a disadvantage rather than an advantage in the health line. Still the fact that up to a definite limit we have the power to increase the size of arm and chest and leg proves once again how truly each of us is master and architect of the body we are building.

He develops Arm Muscles

But what about the material itself — the substance out of which the body piles a muscle into shape and compels it to increase in size whenever it is forced to do unusual work?

Get a piece of lean corned beef from the butcher; have it boiled thoroughly; place a board over it and press down upon it hard enough to squeeze out all the liquid; remove the board, and with a needle of some sort pick apart the fibers as well as you can. Pick them away from each other into finer and finer threads until you think you have reached the limit in size.

Taking the Measurement

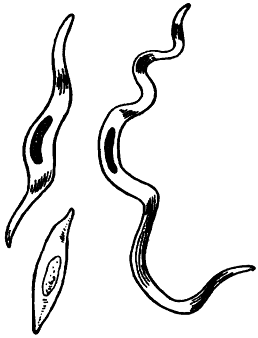
Now if you can get a good magnifying glass, use it in examining one of these bits of beef muscle. You are

able to pull them apart because the outside wrapping of each has been changed by boiling.

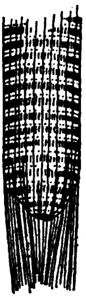
However large or small a muscle may be, and wherever that muscle does its work, whether in creatures that walk or fly or swim, every active muscle is made up of fibers wrapped together in bundles. Shapes are different; size varies from those that draw an eyelid up and down to those that kick a football to its goal; location is different; strength and power of endurance are different; but each muscle that has ever been studied has been found to be made up of fibers. A few of these are wrapped together as a small bundle; small bundles are gathered into bundles that are larger; large bundles become larger yet; and thus from smaller to larger are the muscles built up. Each is a bundle of other bundles; each is adapted in size and shape to the special work which it must do; and every fiber in the bundles, large

MUSCLES OF DIFFERENT SHAPE
(After Schmidt)

and small, is inclosed in its own sarcolemma. This sarcolemma, then, is simply an outer wrap which separates each fiber from all the others. In addition, however, there is a close network of substance called connective tissue, which holds the individual fibers together. In this connective tissue are the tiny blood vessels and the slender nerves which supply blood and stimulus to each smallest fiber of the largest as well as of the smallest muscles of the body. Fine threads of connective tissue also stretch away from each end of the muscle fibers and help form the tendon. Thus, although each separate fiber is a part of the muscle as a whole, it also seems to be an independent small center of power doing its own independent work.



INDIVIDUAL MUSCLE FIBERS



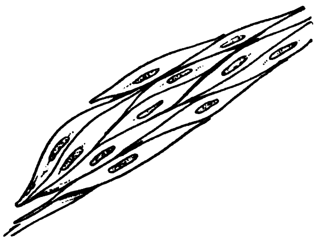
END OF A MUSCLE FIBER

It shows fine threads which help form the tendon

The truth is, however, that no single fiber carries its independence very far. Generally when its neighbors receive your command to go to work it receives the same command. When they rest it rests too. When they are destroyed by suffering, age, or death, it endures all that they endure. Yet, after all, the work of the

millions of fibers which are held together by connective tissue in a single muscle is really the sum of the work which the fibers do separately.

More than this, it is the amount of connective tissue between the fibers that explains the difference between tough and tender meat. With age and with exercise this tissue gradually thickens its substance during life until finally certain muscles become too tough to be eaten without long boiling.



A BUNDLE OF MUSCLE FIBERS

Each is covered with its own sarcolemma; connective tissue is between the fibers

A young chicken is tender because its tissue has not been toughened by work. Tender steak comes from that part of the animal which has had little exercise. When, therefore, we speak of tough and tender meat we really refer to muscles in which the connective tissue has or has not been toughened.

These facts apply not only to the muscles of those animals that are killed by human beings for food, but also to our own arms and legs. Let an athlete bend up his arm for your benefit. You may try to press it with your hand and it will resist you almost like a piece of wood. This is no mystery to you, for you understand that each fiber in that muscle has been toughened by use. If the muscle itself were found in the shop of a

SUPERFICIAL MUSCLES OF THE BODY

Each is fastened to bones that lie underneath

butcher and were offered for sale, a wise cook would refuse to buy it. He would complain that even boiling would not make it tender.

These muscles which we have been studying belong to the skeleton. They are always attached to bones and are therefore called skeletal or voluntary muscles. There are indeed two classes of muscles:

1. Voluntary muscles, of which there are five hundred. They are called voluntary because each is under the power of our will. Through them we walk and run and climb and swim; through them we talk and sing and play the piano and cover ourselves with glory on the athletic field. They serve us when we give our commands. Not so, however, with the second class.

2. Involuntary muscles. These form the heart and are also in the walls of the arteries and of the alimentary canal, — the food tube. They are deaf when we command, but they continue to be busy whether we are asleep or awake, whether we stand or sit, whether we laugh or sigh or cry, run or climb or swim. Whatever we do, they are unceasingly occupied with the internal work of the body, pumping the blood round through heart and blood vessels, caring for the food we eat, and carrying on those central, vital processes of life over which we have no conscious control.

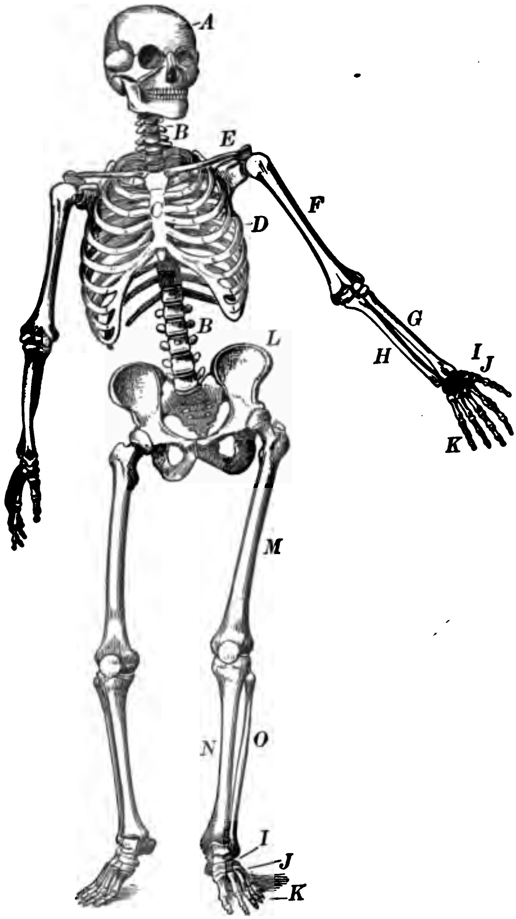
Taken as a whole, the muscular machinery of any human being weighs as much as all the rest of his body put together and weighed in a lump. A few separate muscles are given in the picture on page 27, but there is no special reason why we should learn their names by heart. Nevertheless the biceps is not easily forgotten. It is the muscle best known to every boy, for it may give him pride or disgrace him, according to the pulling power which has been developed in it by its master.

CHAPTER V

STIFF SUPPORT FOR GROUPS OF MUSCLES

A certain teacher who owned a skeleton was in the habit of throwing it over his shoulder when he carried it from the storeroom where he kept it to the lecture room where he showed it to his students. And as he walked it hung from his back as a clattering set of dangling bones. It is true that the separate bones were held together at the joints by artificial contrivances; but that was all. By no chance could the skeleton have stood on its own unaided legs. Those who saw this group of bones for the first time understood as never before that bones are as dependent on ligaments and muscle to keep them together as are tendon and muscle dependent on bone to hold them in place.

Examine a bone fresh from the butcher's. Notice the outside, — firm and closely woven, as it has to be, to supply a surface for muscles to hold to. Look at the inside. There we find looser texture. We know now how it happens that the bone is not only large and strong but light and firm. It is indeed by no means a solid thing. A magnifying glass shows the spaces even better yet. You may now see smooth channels on the outside,

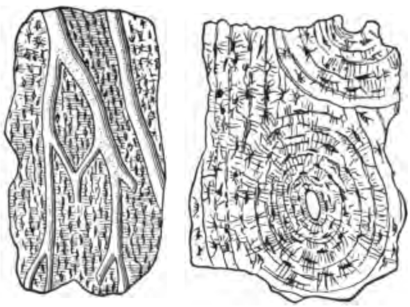


THE CENTRAL SUPPORT OF THE HUMAN BODY

A, skull (composed of 22 bones); *B*, spinal column (composed of 33 vertebræ); *C*, sternum or breastbone; *D*, ribs (12 on each side); *E*, clavicle; *F*, humerus; *G*, radius; *H*, ulna; *I*, carpal (7 bones in each wrist and ankle); *J*, metacarpal (5 bones in the palm of each hand and instep); *K*, phalanges (14 bones that form the fingers and the toes of each hand and foot); *L*, pelvis (composed of 4 bones); *M*, femur; *N*, tibia; *O*, fibula

along which the blood vessels ran, and tiny openings from the surface to the interior, into which the smallest blood vessels went, to keep up the life of the bone.

A chemist will take the same bone and study it in another and a different way. He will keep it in acid for a while and will then tell us that he has taken all the lime out; that he has left nothing but gelatin. He may tie it into a knot and let us see how pliable it is. Taking another bone, he will hold it in fire for a while, and when we touch it the whole structure will go to pieces like a heap of ashes. "That is mostly lime," he will tell us; "I have burned out the organic matter which becomes gelatin when boiled." A cook will take a bone with no meat on it, will boil it for several hours, set the liquid away to cool, and when it is cold she will have a thick jelly to add to her soups. It is gelatin made from the bone. From these and other experiments we learn that bones are made up of lime and of an animal substance, which becomes gelatin after being cooked. We also learn that in old age bones



A *B*

BONE CUT LENGTHWISE (*A*) AND CROSSWISE (*B*)

Blood vessels and nerves run through the canals, and these canals are joined to each other by channels yet more minute

contain the most lime, and that the younger the child the less lime is there in his bones.

It appears that the proportion of lime increases from year to year through life, until finally the entire system of bones becomes too brittle to make it safe for aged people to risk even so small a thing as a tumble on the sidewalk. Many an older bone has snapped off short where a younger bone would have saved itself by bending a trifle.

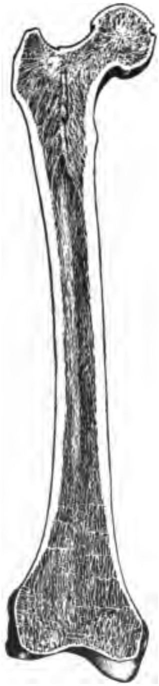
TIED IN A KNOT

After acid has taken the lime from it

This brings us back to the subject of the reason why children have the power to influence the shape of their bones while they are young. The animal part not only prevents bones from being brittle, but it keeps them pliable.

Knowing this fact, I applied it to the case of a friend of mine. She was getting a hollow chest and I told her how to save herself. "It will be hopeless after you are twenty," I said. "But you are only twelve now. Your bones are still pliable. If you will raise your chest with vigor, fill your lungs with air, hold yourself in this position for three or four seconds at a time and do it many times a day, you will compel your bones to take the shape for which you will be thankful the rest of your life." I suggested that she give special attention to the matter on the way to and from school each day. She liked my scheme so

well and practiced it so faithfully that within a month the curve of her chest had improved.



A Bone Cut through Lengthwise

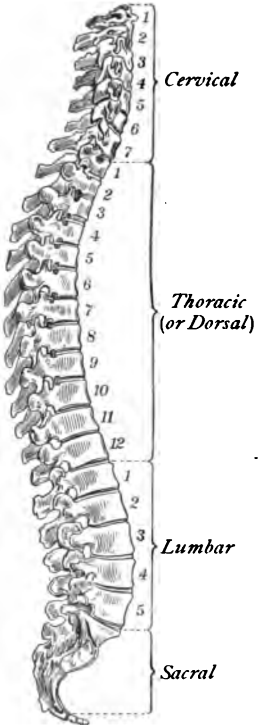
The outer layer is compact and firm, the inner substance is a network of canals and spaces; thus are bones both light and strong

In so far as you can, feel of your own bones and decide for yourself why each has its own particular shape. You will find long bones for legs and arms; flat bones for shoulder blades, breastbone, and hips; curved long bones for the ribs; curved flat bones for the skull; and you will discover that these latter are so closely joined together that your head seems like a solid, single bone. There are queer, jagged bones, one above the other, in a column, for the back, and many small bones of hand and foot deftly held together, each doing its part in stiffening up the body and in making it serviceable to us.

All grown persons have the same number of pieces to the skeleton, but the names of our two hundred separate bones are of no vital importance to us. Still the figure on page 31 gives a few, because it seems almost discourteous to label such useful articles as nothing more than long and short and flat and crooked bones.

Most important of all, perhaps, is the graceful column

of the spine. Many a man has lived for years without an arm, without a leg, without bones of various sizes and shapes; but no man has ever been able to live for a moment without that pile of thirty-two small bones that holds his head erect, that keeps his ribs in place, and that guards the treasure of his spinal cord.



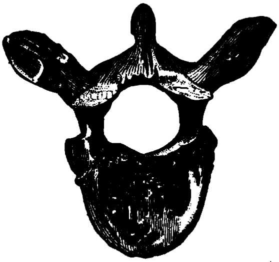
A SIDE VIEW OF THE SPINAL COLUMN

Each group of vertebræ has its special name

In this spine each separate vertebra is held to the one above it and to the one below it by muscles and ligaments on each side, and because of their muscles and ligaments these individual vertebræ are no more responsible for the shape they take, or for the twists and curves they join in making when a gymnast bends his back from side to side, than are the dumb-bells and the pulleys which the same gymnast uses; for the bones of the spine simply rock back and forth upon each other, according as muscles on this side or that give the needed pull.

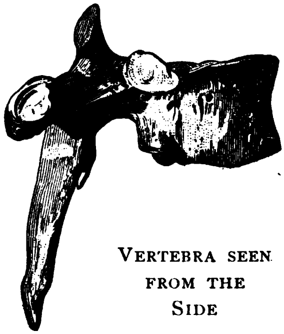
Just here recall a few facts. As we know, young bones are largely cartilage; they take new shapes if they are put under special, oft-repeated

pressure. A child at a school desk easily gets into the habit of sitting with the vertebræ pressed against each other at the same angle every day. Small muscles do the



VERTEBRA SEEN FROM ABOVE

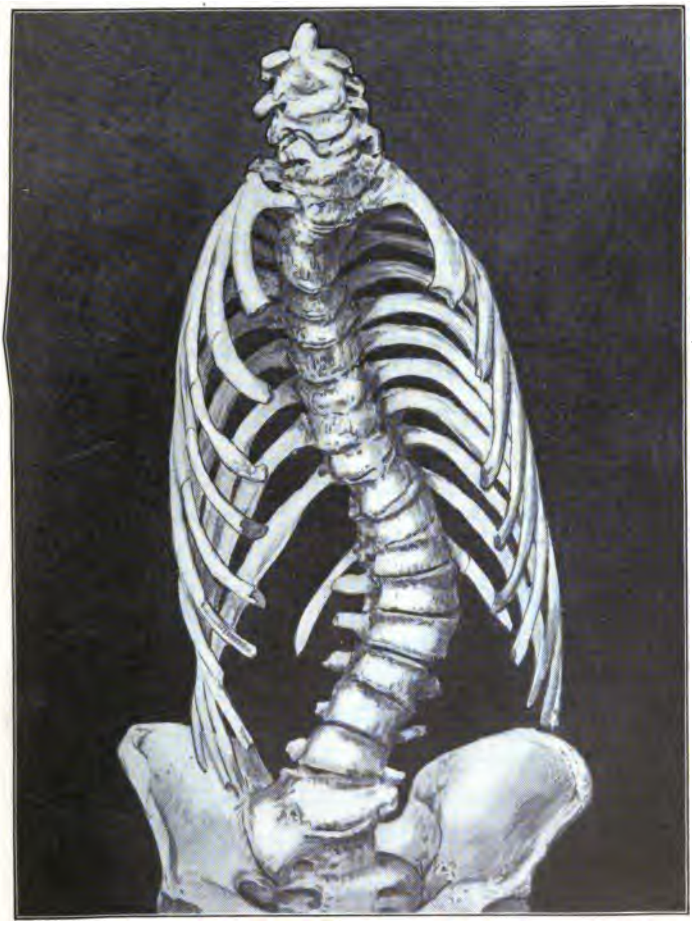
pulling; they grow strong as they are exercised. In the meantime, also, the separate vertebræ are yielding to pressure. On one side they are growing thinner; on the other side, not being pressed upon, they grow thicker. The result is inevitable. Some of the bones of the back will become wedge-shaped; and, sad to say, a back that has developed wedge-shaped vertebræ — vertebræ that have kept their wedge shape until they are hardened for life — can never hope to be straight again.



VERTEBRA SEEN FROM THE SIDE

Certain other bones may, however, be changed by what they are compelled to do. Suppose you decide that you wish those that are larger and rougher. You may travel a straight road to that definite end. Work the muscles which are fastened to these bones; work them hard; be persistent and the result will come.

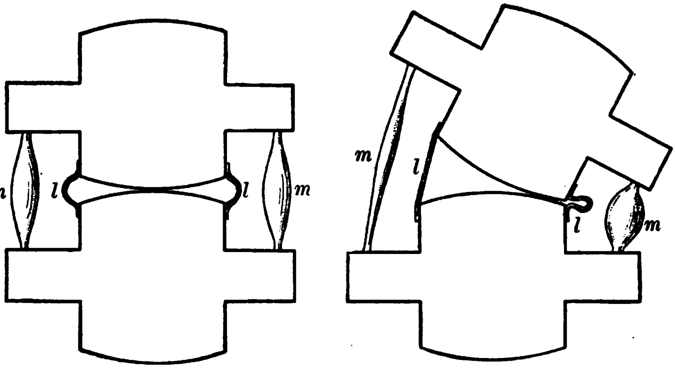
In studying human skeletons it is not difficult to pick out the bones of such persons as did vigorous muscular



Wedge-shaped Vertebræ

Pressure was too often on the same side

work by their heavier and rougher character, while the thin walls and fragile internal substance of other bones show that the muscles of the arms and the legs were paralyzed or wholly useless.



BLOCKS SHOWING HOW THE VERTEBRÆ ARE HELD TOGETHER BY LIGAMENTS AND MUSCLES

l, ligament; *m*, muscle

Evidently, then, active exercise leaves its mark even on the bony part of the body. Thus, without making any close examination of our own separate bones, we may know, by the exercise we give them, what their prospects are year by year.

CHAPTER VI

BONDAGE AND FREEDOM FOR THE FEET

As I looked at the small, deformed feet of our friend the Chinese lady, I easily imagined what had happened

CHINESE SHOES TWO AND A HALF INCHES LONG

The huge ankle shows how deformed the foot really is

to the bones that made up the bulk of the huge ankle above the shoe. No one saw this ankle. All we saw

was the dainty, handmade shoe two and a half inches long, embroidered in silk of lovely shades, and made of cloth and silk above a leather sole.

For hundreds of years Chinese custom demanded that all the women of the upper classes in the empire should hobble through life on deformed feet. Some feet were larger, some were smaller, but in certain regions the most stylish shoes were two and a half inches long. This, then, was the size of foot which the ladies wished to have. To secure it a mother began to bind the feet of her daughters when the girls were five or six years old. Often the girls themselves wished to have this done. Nevertheless the bandages were drawn so tight that night after night young girls have cried themselves to sleep in China because their feet in their bandages hurt them so.

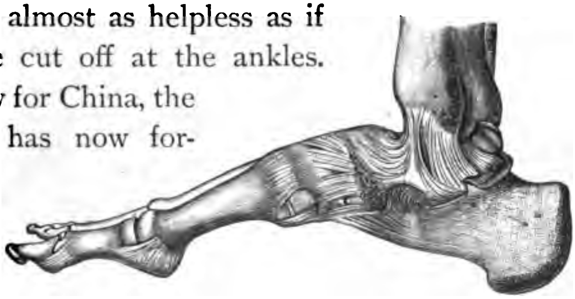
THE BONES OF THE FOOT

Almost never, however, were the bandages left off. They were changed from time to time. But when they were put on again they were pulled ever tighter until in the course of years the child secured the foot which could never again help her by the movement of the bones which formed it. The toes had been drawn in under the foot; the heel had been drawn forward to

meet them; muscles and tendons had been kept from growing, while the bones themselves had been obliged to take strange new shapes as they fitted themselves into such space as they could get.

When I saw my friend the Chinese lady, her feet were set for life. They gave her little discomfort, and she herself now took entire charge of their binding. Until she dies, however, she must hobble through her duties and her pleasures almost as helpless as if her feet were cut off at the ankles.

Fortunately for China, the government has now forbidden foot binding throughout the empire. At last, therefore, the girls of the land may sleep in comfort, and the future ladies of the Celestial Empire may walk about with such ease and grace as can only come when the entire foot is at the service of the body.



BONES AND LIGAMENTS OF THE FOOT AND ANKLE

Even in other lands than China there is often lack of comfort, while very often all trace of grace is also lacking. When you see your own bare foot to-night compare its natural shape with the shape of fashionable shoes. Remember the following facts and decide what the sensible course of action is:

1. Each foot is made up of twenty-six small bones.

2. These bones are joined to each other by ligaments and muscles.

3. No foot can be in thoroughly good order, neither can it exercise itself with ease, unless each muscle, bone, and ligament is allowed to move with freedom.

4. If the arch of the foot is flattened, health is apt to suffer. Indeed, it is so serious a matter to be flat-footed that men with this handicap are refused admittance to the United States army. Test the condition of the arch of your own foot by dipping the bare sole lightly in water, then pressing it on blotting paper. The imprint made will show whether the foot is flat or arched. Those who stand still for hours every day are in danger of flattening their feet. While they stand they should therefore save the arch by resting the weight of the body first on one foot for a while, then on the other. If you have any tendency to flat feet, help yourself by the following exercise. Stand with toes turned inwards, and while in this position rise as high as you can on your toes. Do this one hundred times, twice a

A *B*

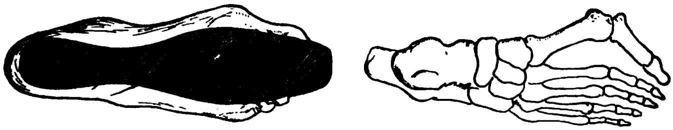
FOOTPRINTS

A, an arched foot; *B*, a flat foot

(After Schmidt)

day; or, instead of counting, rise and fall on the toes until the muscles are tired.

5. A young foot grows by day as well as by night, and should never be cramped when it is in use. This does not mean that a shoe should be too loose for comfort. It means that the foot is one of the most useful pieces of machinery we have, and that we are in better health and have a more graceful walk when our feet are not uncomfortably hampered by our shoes.



A WOMAN'S FOOT DEFORMED BY FASHIONABLE SHOES

(After Schmidt)

It is a sad fact that multitudes of men and women would be filled with confusion if they were obliged to show the shape of the feet they have secured for themselves. The explanation of the shape lies, of course, in the shoes they have worn.

The best health of the foot calls for attention to the following points:

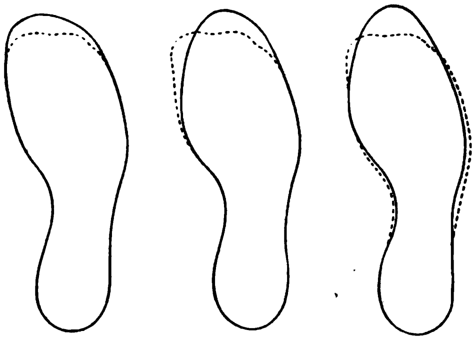
1. Wear shoes with soles as broad as your foot is when you stand with no shoe on.

2. Do not lace your shoes so snugly about the ankle that the pressure will interfere with the

circulation of blood. Cold feet often come from tight shoes, tightly laced.

3. Let the heels of your shoes be broad and low.

4. Never wear tight garters. They interfere with the movement of the blood through the blood vessels.



A *B* *C*

THE SHAPE OF THE FOOT AND THE SHAPE OF THE SHOE

Dotted lines show the natural shape of the foot; solid lines show the sole of the shoe. *A*, correct shape; *B*, the large toe is drawn in too far; *C*, the shoe is too narrow. If you wish a comfortable and a well-shaped shoe, get one that is wide enough but longer than you need. This will give you the appearance of having a slender foot

5. Remember that tan shoes are rather better than black shoes for summer wear because they do not keep the feet so warm.

6. Keep the feet dry and warm, but if possible avoid overheating them.

7. Be sure that your shoes are large enough to give your toes as well as your ankle a chance to move and to be useful when you walk.

CHAPTER VII

ASSISTANCE FROM JOINTS

During the summer of 1905 the following item appeared in the New York *Times*:

ELEPHANT'S ANKLE SPRAINED

ALICE SLIPS ON A BANANA PEEL AND GETS A BAD TWIST

Alice, the big elephant in Bostock's at Coney Island, has a sprained ankle. It is a bad sprain, too, mainly because it is a big one; there is nothing slender about Alice's ankles. Alice was crossing a gangway into the arena when she slipped on a plebeian banana peel.

Alice saved herself from falling by winding her trunk around the leg of her mate, Roger. Alice's ankle is now in a big plaster cast, which makes her leg look like a huge fireproof pipe.

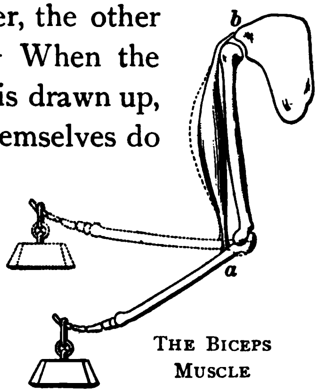
No doubt Alice, the elephant, suffered as much from her sprained ankle as did my friend Alice, the human being, who sprained her ankle at about the same time by slipping on another banana peel. In each case ligaments that held the bones in their sockets and tendons that held the muscles to the bones were more or less pulled from their firm fastenings. And when a pull does as much mischief as that, recovery is often slower than in the case of a broken bone.

Lower Leg with its Muscles and Tendons
(After Schmidt)

Bend your ankle in every possible direction and learn what you can about it from your sensations as you twist it. Draw up the muscles in the calf of your leg so hard that you think you feel the spots where they are fastened to the bones above and below. Now recall facts which you know, and decide what is taking place. Remember that muscles end in tendons, and that it is by its tendon alone that a muscle is able to move the bone which supports it.

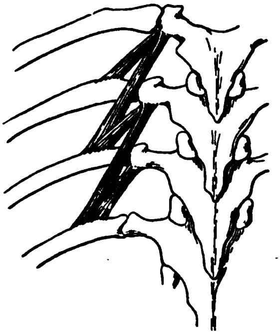
For the muscle of the calf of the leg, tendons are fastened to the lower end of the thigh bone and to the heel bone, and the work of contracting is done between the two firmly held points. Through this muscular contraction we walk and jump and run to win the race or to take our exercise. Tendons must be strong indeed when they refuse to give way even under the tremendous strain which is put upon them. Follow the facts about the biceps. It is fitted for one particular kind of work, and it does

its work through the help of tendons which hold one end of the muscle to the shoulder, the other end to a bone of the forearm. When the muscle contracts the lower bone is drawn up, because, although the tendons themselves do not contract, they cling to the bones and thus help do the pulling. Without tendons, indeed, no muscle could ever move a bone. Muscles of the back are held to the spine, which they control by tendons; neck muscles hold the head in place by tendons; and each of the twenty-four ribs has its own supply of muscles and tendons. By the contraction of the muscles the tendons pull the ribs up where we wish them to be.



THE BICEPS MUSCLE

When it contracts the lower bone is drawn up; the dotted line shows that the muscle is then thicker and shorter



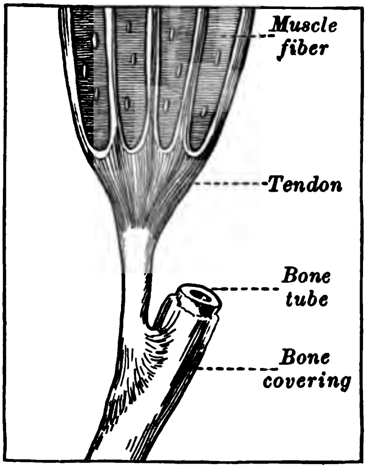
MUSCLES BETWEEN THE RIBS

When the muscles contract the ribs are drawn up

The serious part of strained tendons is that the union of tendon and bone is so close that, in a bad sprain, the outside covering of the bone itself is sometimes pulled away with the tendon. When this happens a sprain is a far more serious affair to cure than a clean-cut bone break; for the broken ends of a

bone knit together far more readily than do the torn ends of a tendon.

After all, however, the ligaments and bone surfaces are quite as important to us as the tendon, because they determine the direction in which a bone must move. Some of them allow movement in one direction, some in another. Prove this for yourself. By every twist that you can make, try to decide where your joints are and what style of joint each one is. You will find that some work back and forth like a hinge, while others have the power to move back and forth and sidewise too. The different kinds of movement are the result of different kinds of joints. Each is needed in its particular place.



MUSCLE ENDING IN TENDON; TENDON FASTENED TO BONE

(After Schmidt)

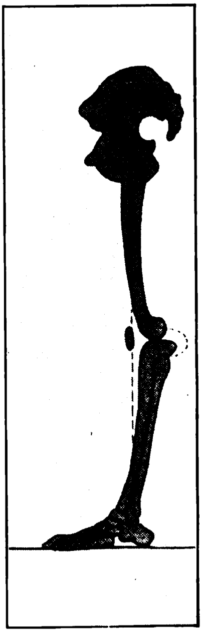
Begin with the hinge joint where your skull is joined to the upper end bone of the spine. This allows you to bend your head up and down, and nothing more. But just below, between the next two bones, is a joint of another sort. This allows you to turn your head from side to side. Thanks to the two joints acting as one, you can move your head in every direction.

Whirl your arm round and round and know that you are using the most movable joint in the entire body. It is a so-called ball-and-socket joint. The hip is supplied with another of the same kind.

When we think of the work which the hip and the knee have to do for us, and of the strain we are ready to put on them at any moment, we understand why the hip and knee joints should be among

HIP JOINT DRAWN OPEN

Notice the ligament which holds the ball in its socket



BONES AND JOINTS OF THE LEG

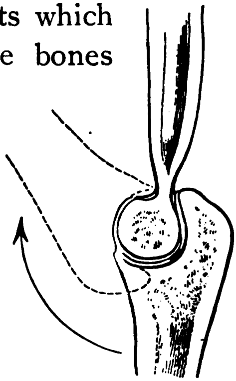
the firmest and the strongest points of the whole body.

The knee itself is a wonderful structure. And here we have an admirable chance to study ligaments. They are firm and white and tough, being in all this quite like

THE BACK OF THE KNEE JOINT
(After Schmidt)

tendons. Moreover, when once torn they are as slow to heal as is a tendon. Ligaments do the work of holding bones to each other, whereas tendons hold muscles to bones.

The great hinge joint of the knee is supplied with ligaments which allow it to bend one way, but which absolutely forbid any bending in an opposite direction. If it were not for the stout ligaments which hold the bones together in a definite relation, our knees would bend backwards and forwards with equal ease, and walking would be forever out of the question.

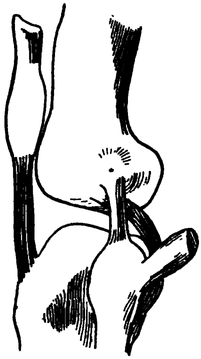


CUT THROUGH THE HINGE JOINT OF THE ELBOW

Elbow as well as knee, fingers as well as toes, — all act on the plan of the hinge.

Two kinds of joints are thus seen to be most prominent in the body of man: (1) ball and socket; (2) hinge.

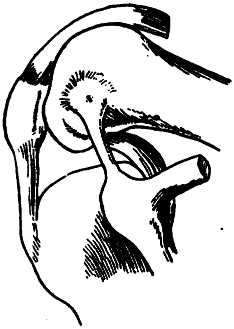
This completes the outline of the bony and muscular machinery of our bodies. We have seen that the ends of our bones are shaped to meet each other, that they



KNEE JOINT WHEN STRAIGHT

Notice the position of the knee pan

(After Schmidt)



KNEE JOINT BENT FAR OVER

Notice the ligaments that hold the bones together

(After Schmidt)

are carefully fitted together, that tough ligaments hold the one to the other, and that muscles end in tendons which draw the bones in such directions as the joints allow.

CHAPTER VIII

THINGS THAT HINDER STRENGTH AND SPEED

Various public schools were in a state of high excitement during the spring of 1905. The following item in the New York *Times* shows the reason for it:

> Schoolboy athletes are to hold their contests on the roofs of the available public school buildings in the boroughs of Manhattan and Brooklyn. . . . Each school is to enter five boys in each individual event, and two teams in each relay race. Medals will be given to first, second, and third in each event, and a trophy will be presented to the school scoring the most points.

Boys under thirteen, in these events, competed in the potato race, the standing broad jump, and the relay race for teams of four boys, each running twice across the roof. Boys under fifteen had the same potato race, with running high jump instead of broad jump; and in the relay race of four boys, each ran four times instead of twice across the roof. Boys over fifteen did other things in addition.

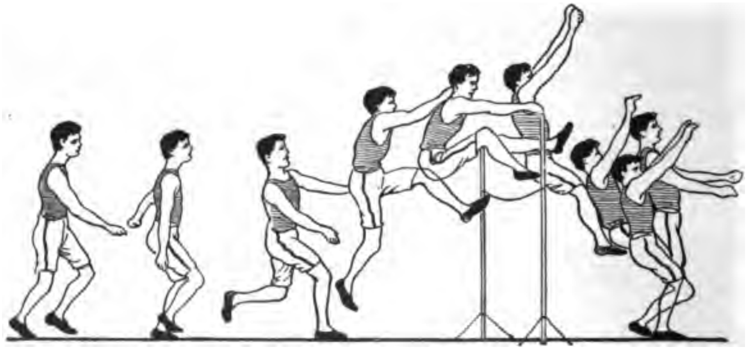
Throughout the spring of that year, wherever New York boys could find a roof large enough or a space of ground unoccupied, there they went for fun, for exercise, and for trophies. But the doctors of the city, the fathers, the mothers, and the teachers believed most in the exercise.

They were sure that through it city boys might gain the greatest prize of all — good health; and they were more anxious to have the city turn hundreds of thousands of boys and girls into healthy, well-developed, long-lived men and women, than to have it turn out a few wonderful athletes who should outrun and outjump all other boys in all other cities in America.

THE START AND THE FINISH OF THE HUNDRED-YARD RUN

The truth is that never before in the history of the world has so much attention been paid to the health of children as in this twentieth century; for, in the first place, the laws of health are better understood to-day than ever before, and further, the children themselves are learning to judge what is best for the body. They already know scientific facts which show how an athlete may increase his chance for success or diminish it.

This accounts for the self-denial which many of them practice. They have learned that the best athletic trainers of college teams and of professional athletes throughout the country strictly forbid their men to use tobacco in any form. The boys also know that the reason for this is the fact that tobacco so affects the heart as to reduce a man's ability to do his best muscular work.



A HIGH JUMP AT NINE CONSECUTIVE MOMENTS

To do his best his heart must be in good condition

(After Schmidt)

Boys have learned from these same trainers that alcohol is strictly forbidden because it reduces the power of the muscles. Being keen enough to see that that which helps college students and professional athletes is precisely what will help them, the most determined of these boys give up their cigarettes and do not so much as begin to use alcohol. Multitudes of other boys are, of course, still smoking cigarettes, but in

thousands of these cases ignorance explains their willingness to do it.

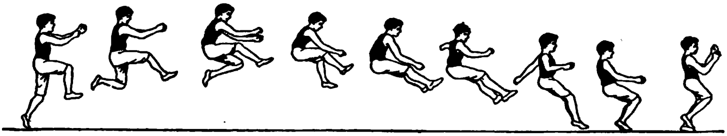
Any class or school that is interested in making scientific investigations for itself might appoint a committee to look into the school records and into the running and jumping records of their smoking and their non-smoking classmates. Investigations of this kind must be carried on for months, or for a year if they are to prove anything.

MUSCLES TIGHTENED FOR THE JUMP

(After Schmidt)

As a rule, at the end of this time it will be found that those boys who use the most cigarettes are doing the poorest work both in the class room and on the athletic field. The class or the school that wishes to make the best records will therefore be forced to omit from among its contestants all those who use cigarettes. It will decide that it cannot afford to reduce its chance for winning just because certain boys are either ignorant about the laws of the body, or because they are already victims of the cigarette habit.

Why did the American army have to refuse hundreds of men who applied and who were ready to face death for the sake of their country? In a large number of cases it was because these men had a certain weakness of the heart which was brought on by tobacco, and because, when a man's heart is troubled in this particular way, he is not likely to be able to endure the exercise which he will have to meet as a soldier. His heart is not strong enough to risk it.



A Running Broad Jump from One Foot

It shows the work done by different muscles from the moment the man jumped until he stood on his feet again

(After Schmidt)

The same is true for athletes of every age and size in whatever land they may be. He who is in the habit of using cigarettes should be careful how he ventures to do anything that will call for sudden, or violent, or vigorous use of his muscles and his heart. Although he may still be able to run as fast and to jump as high as his friend or his schoolmate who does not smoke, yet the probability is that he has the sort of heart that the American army often refuses to accept, — the heart that no soldier can afford to own. And the man who is

afflicted in this way cannot expect to do his best on the athletic field.

In this connection it is interesting to know what the leading trainers of the country actually say about it.

Mr. Charles E. Courtney once wrote from Cornell:

> I have found in my experience that young men are much better off, and do better work, without alcoholic stimulants than with them, and they are, therefore, absolutely prohibited in our training. As to tobacco, I believe young men do better work when not using tobacco than when using it, and it is prohibited in our training here at Cornell University.

In 1900 Mr. McBride, captain of the Yale football team, wrote:

> It is absolutely necessary for a college or school athlete who is striving to win a place on any team to have endurance; especially is this true in rowing and football. This can be accomplished to the greatest degree only by abstaining from the use of tobacco and alcoholic drinks while in training for said team.

In 1901 Mr. Edwards, captain of the Princeton football team, wrote:

> There is nothing which goes to make a better athlete, nothing which gives a man greater power of endurance, than total abstinence from the use of alcoholic drinks. . . . No one is expected to use tobacco. A man who is using tobacco and alcohol contrary to orders during the season is easily detected, and is dropped from the squad.

In 1906 Mr. A. A. Stagg of the University of Chicago wrote:

> We have never had a really successful long-distance runner at the University of Chicago who was a smoker, and several of our men who

have been successful, like Lightbody, are most abstemious in their training and do not smoke. The best sprinters and middle-distance runners we have had have also been men who were very particular about their training for several months of the year. . . . In football, as in other endurance tests, there is no question at all in my mind that the man who smokes does not come up to the level of the general run of nonsmokers.

In 1906 Mr. Gianini of the New York Athletic Club wrote:

> My opinion is expressed best by stating that I forbid the use of tobacco in any form by men under my charge while training.

The Arctic traveler, Nansen, was asked by a neighbor, "Did you take any alcohol with you when you left the Fram to make your heroic expedition by sledges?" "No," said Nansen, "for if I had done so, I should never have returned."

CHAPTER IX

THE HEART WHEN IT IS AT WORK

Let some one hold a watch and be prepared to make reports while you and perhaps your friends test yourselves in various ways.

COUNTING THE PULSE BEAT

Stand with your finger on your pulse at the wrist, and let him who holds the watch decide when the counting is to begin. He will say, "Get ready—now—begin." When he says that last word each child should, for himself, start to count the regular throb of the pulse which he feels under his finger. Let him keep on counting until, at the end of one minute, the timekeeper says, "Stop." You will then have your record.

If you are not excited, if you have not been exercising hard beforehand, if you have made no mistake in your counting, the number of beats which you feel will show

what your regular everyday pulse beat is. This is an important point gained. You have secured your standard for the standing position. You are ready for the next test.

Stand perfectly still, and, while the timekeeper follows the time again, open and shut your hand as fast and as hard as you can for an entire minute. Then once more count your pulse. You may find that it has gained a trifle. This will depend on the vigor with which you have worked the muscles of your hand. In any case, however, the muscles there are small and you will not get much of a result in the way of a more rapid beat.

He counts both Pulse Beat and Heart Beat

Turn, therefore, to the leg muscles of the body. Use them vigorously. Let each child run up one flight of stairs and back, and at once count the pulse again. You will find a marked change. From eighty or over at the start, you have probably increased the count by one half or more.

In addition to the above tests make one more. Even while the fingers of your left hand are feeling the pulse in your right wrist, place your right hand over your heart. You will discover that the pulse beat and the

heart beat occur at the same instant. And now, if you were not uncomfortably out of breath after the run up one flight, try two flights for a second test and notice that the number of beats has increased both at the wrist and at the heart. You have proved for yourself that the pulse beat may be depended on to show what the rate of the heart beat is.

The following table shows what such exercise did for a small class of children in a New York school. The letters of the alphabet stand for the names of the children.

TESTS SHOWING EFFECTS OF EXERCISE ON THE HEART BEAT PER MINUTE

	Normal Pulse	After Short, Quick Run
A	85	130
B	83	142
C	71	113
D	85	95
E	85	113
F	88	120
G	83	95
H	84	87
I	90	114
J	98	130
K	85	94
L	85	110
M	83	104
N	87	115

Each child was tested again within a minute after the run, and already the pulse was found to be beating more

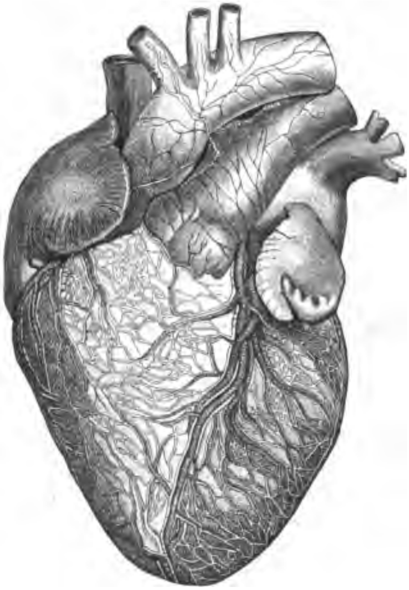
slowly. This rapid return to the normal beat is the sign of a healthy heart.

At different times, on different days, test yourself in other ways. Count your pulse when you get up rested in the morning and when you go to bed tired at night. Count it before and after your cold bath in the morning. Count it before and after any variety of exercise that interests you. For example, run to school one morning, walk to school another morning, and compare the results of both with your standard. Compare the number of beats of the heart that has done hard work with those of the heart that has done light work, and learn to know what gives your heart the most exercise. Knowledge in this line will serve you well in deciding how to do the most for yourself in the shortest space of time. What you learn now will be applied in a later chapter.

It would be quite worth while to keep your different records written down in a notebook of some sort for future reference. Already, however, you have learned that exercise makes the heart beat faster, and that the larger the muscles are, and the harder the work you give them to do, — running, for example, — the more exercise will you give the heart. You have also learned that the pulse may always be trusted to tell important facts about the action of the heart.

It is for this last reason that a doctor feels the pulse of his patient. By the regular or the irregular beat of

that pulse, by the way it hurries and by the way it drags, he is guided in his judgment as to what the condition of the patient is, and what ought to be done to help him. The heart, indeed, is one of the vital centers of our activities. We are well or ill, we live or die, through the work which it does or fails to do. Yet the ignorant are often misled by its action. Many frail women fear to take exercise lest they overtax the heart.



THE HEART AND ITS GREAT BLOOD VESSELS

We are well or ill, we live or die, by the work it does or fails to do

This, then, is one extreme to which a person may go. On the other hand we have the bicycle rider who overtaxes his heart so persistently as to injure it for life, and the boys who run long or hard races before their hearts have been trained for such violent exercise.

It seems that the heart is a strong, hollow muscle, about as large as the fist of the one for whom it works; and that even when it is not put under extra pressure it does more work than any other muscle in the body. It

lies under the ribs, between the two halves of the lungs, and keeps up its beating from birth to death. It does, indeed, take more exercise than any other muscle; nevertheless, like every other muscle, additional exercise gives it strength, while lack of additional exercise leaves it weak.

THE CHAMPION PLAYER AT A CRITICAL MOMENT

In training this important muscle we must remember that most human beings have sound hearts that need to be treated in a reasonable way.

A neighbor of ours had taken no special exercise all winter, but when spring came he began abruptly by playing one set of tennis after another, without resting between the different sets. The end of it was that for many days and nights his heart kept up a rapid beating. For three weeks, indeed, it refused to come down to normal, and during this time the man dared take no exercise. He knew it would be unsafe.

If he had been careful to begin his tennis playing gradually that spring, increasing the amount from day to day, he would have done better work, would have spared his heart the overstrain, and would have saved himself

those weeks of time when he could take no vigorous exercise whatever.

Watch those who race to catch a train or a car. By the way they breathe you may know what the heart is doing. You will also be able to tell which of the running men and women have trained their hearts for sudden sprints of violent work and which are pressing untrained hearts into unusual service. College students often run by the mile across the town and out into the country. They are training not only the many muscles of their legs but also the one muscle of the heart and their breathing apparatus. They wish to train their leg muscles, while at the same time they secure for themselves hearts and lungs that will be useful as long as their legs are able to keep up the running.

A doctor whom I know speaks of a man whom he himself trained. He says:

When I took charge of him the man could not run as far as from here to the door without fainting. He simply had a muscularly weak heart, excited by nervous shock and overwork, worry, deficient nutrition, and lack of sleep. I first discovered that there was no organic disease. Nothing but plain building up of muscle was needed. Then I went to work and started to build up that muscle. I would have him run a few steps and then lie down three minutes, then run a few steps more and lie down. I stood by, keeping track of his heart, not allowing him to do enough work to send it above one hundred and not letting him run again until it got back to normal. I kept him at it half an hour three times a day, from day to day increasing the doses; that is,

I stuck to the medicine, but I gave very small doses, — doses suited to the strength of heart he then had. In three months that man could run eight miles an hour with great ease and comfort. Since then he has not known that he has a heart.

This doctor also speaks of a friend of his who ran up eight flights of stairs because of a fire, and so over-strained his heart that it has never been right since.

The point of all this is that when the heart has done what it comfortably can, and then has to do still more work and keep it up, it stretches too much for its own good. And worse still, if it is stretched badly enough it stays stretched. This is part of the trouble with the overworked heart of the bicycle rider. Athletic trainers understand these facts thoroughly. It is therefore as much for the sake of the muscle of the heart as for the benefit of leg muscles that they insist that only those who have been trained for the contests shall be allowed to compete in athletic games. Otherwise the untrained person might faint in the midst of the sport, and this is not only harmful to himself but quite as unpleasant for those who are watching the contest.

The safe rule, is to give the heart all the exercise it can comfortably take at one time, and to increase the amount as fast as its power increases.

As a rule, the actual size of the normal heart is proportioned to the work it has had to do. Animals kept in cages and captivity have been examined after death and

their hearts have been seen to be smaller than the average heart of wild animals of the same species. In proportion to his size the heart of a stag is about twice as large as that of a pig. The reason is plain. The stag lives by exercise which makes the heart work; the pig, excepting in the wild state or in pasture, seldom indulges in any unusual exercise.

Provided the matter is not overdone, nothing is better for heart development than exercise which calls for endurance. A quick run for a minute, or a good jog trot lasting five minutes, is as good as anything that can be devised. Run as you go to school in the morning; run on the way home at night. At each time run a little, then walk a little. Run only so much as you can quickly recover from. Indulge when you can in a good outdoor game. By your pulse beat and by the way you keep your breath or lose it you will know what you may do. It is much better to begin with too little exercise than with too much, for you are going to make steady gain whatever your starting point is; and you gain most by going moderately at first.

Throughout his entire life he who has a well-developed heart will also have more vigor, more power to endure, more courage than he otherwise would have.

CHAPTER X

DISCOVERIES BY A GREEK AND BY AN ENGLISHMAN

Galen, the Greek, was born in the year 30 A.D. He made discoveries about the body, practiced medicine in Rome, and for fourteen hundred years afterwards what he had believed and written about the body of man was taught in every school of medicine in Europe.

This domination continued until William Harvey, an Englishman, made his discoveries. In 1616 we find him lecturing in London. He was thirty-eight years old at the time. When he died, at the age of seventy-nine, he had added such a volume of scientific facts to those which Galen had discovered, that during the three hundred years since then the two names have stood side by side on the honored roll of those who have transformed the beliefs of the human race.

Naturally, of course, Harvey began his work where Galen and his successors left off. He built on foundations which Galen had laid, but he was as independent of past beliefs as Galen himself had been. Whenever he had the opportunity, whether with men or animals, whether with those that were well or ill,

alive or dead, he studied their bodies and gave special attention to the action of the heart and to any connection which it might have with the blood supply.

In the case of wounded animals, at different times he laid his hand on the heart and noticed that with each throb the blood left the wound with a spurt, and he saw that blood which spurted in jets from a wound was always of the bright red kind.

Then too he came across wounds that bled in a different way. With them the blood simply poured out in a quiet, dark-purplish stream. In such cases there was no sudden increase of flow with the heart beat. He found that the same was true for wounds in man and beast alike; that is, bright blood came in jets while dark blood came in a quiet stream. Moreover, he saw that it was always true that when the heart beat slowly the pulse at the wrist was slow too.

These important observations, added to many experiments which he himself made, drew Harvey's thoughts more and more to questions about circulation. It then occurred to him that the heart might be a special machine for pumping bright-colored blood out into the arteries, and the thought of such a possibility was exciting even to himself.

Through yet other experiments and constant thought on the subject, his suspicions gradually changed to convictions. He became very sure that every pulse beat in

the artery at the wrist means that the heart has pumped a fresh supply of blood into the large artery, the aorta, which is joined directly to it, and that the elastic tubes have expanded throughout their entire length to make room for it. He knew, as we do, that the largest arteries are buried deeper in the body than the veins, and that only at certain spots do they come near enough to the surface to allow us to feel the effect of the heart beat. He noticed that there is never any throb in a vein, and this strengthened his conviction that no vein ever receives blood directly from the throbbing heart.

By traveling the road which he took we have come upon Harvey's first great discovery:

The heart pumps blood into the arteries.

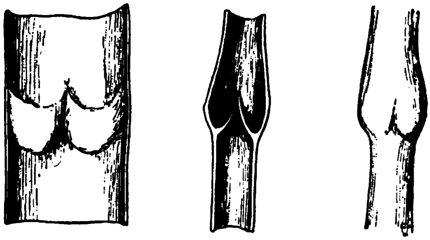
The scientific world was even more excited over this announcement than it had been over Galen's discovery. But Harvey himself went quietly on with his investigations. He saw that the heart pumps by contracting and expanding; that the average human body holds about six quarts of blood; that the heart sends about half a tumblerful of blood into the aorta every time it contracts; and that, since the heart beats about seventy times a minute, an enormous quantity of blood must be squeezed out of it during each half hour.

He did some multiplying, as we ourselves might do just here, and decided that if the heart sends out over

one thousand tumblerfuls of blood every hour, and if the body holds no more than twenty-four tumblerfuls, — that is, six quarts, — the enormous supply must be explained somehow. Where did it all come from? This was Harvey's next great problem.

One sign after another led him to suspect that the veins might hold the explanation. He therefore tested veins and arteries too, as we ourselves may do.

Draw up your sleeve, swing your arm round your head once or twice, let it hang by your side for a minute, and you will notice that some of the blood vessels appear as dark lines under the skin. Stroke these lines down towards the wrist. They are veins, and the little bunches which stand out show where the valves have caught the blood. Remember that these valves are on the inside lining of every vein, and that they always open towards the heart. During the time, then, that the blood in the veins flows steadily towards the heart, the valves lie flat and smooth against the lining and you would not suspect their presence. But try to drive that blood away from the heart, and quickly every valve is so



A *B* *C*

POCKET VALVES IN THE VEINS

A shows a vein slit lengthwise and laid open; *B* shows a vein cut through lengthwise; *C* shows how a vein looks from the outside when its valves are filled with blood

filled that it stands out like a little pouch and helps block the passage of the blood backwards. The nature of the veins, therefore, helped Harvey on towards his next discovery.

While your left arm is still uncovered, press and squeeze it with your right hand, stroking towards the elbow to hasten the blood out of the veins. Now, as quickly as you can, tie a firm bandage about the arm just above the elbow. Tie this bandage as tight as you can without giving yourself pain. Within a few seconds notice how you feel, and notice the color of your hand. It remains pale and it grows cold.

A HANDKERCHIEF AND A STICK TO COMPRESS AN ARTERY

As the stick is turned the bandage is pulled tighter

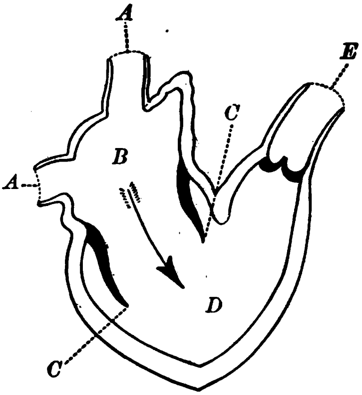
(After Tracy)

Arteries are buried deep, veins are near the surface. Your bandage is therefore checking the flow in both sets of blood vessels; and because no blood can get into the arm, the color of it stays about as when you tied the bandage. Above the elbow, however, you feel a throbbing, because the blood in the arteries is held back by the dam of the bandage. Loosen this bandage a little. You have now lifted the pressure from the arteries, and blood hurries

towards the hand. But the veins are under pressure still; notice what is happening. Blood is entering through the arteries; it cannot escape through the veins because of the pressure of the bandage. As a result the hand grows red and swollen from its unusual supply. Release the bandage entirely, and in almost no time those veins have relieved themselves. Blood is once more streaming upwards.

Such experiments as these and others led Harvey to his second announcement. He declared to his astonished friends that:

The heart receives its entire blood supply from the veins.



THE RIGHT AURICLE AND VENTRICLE

A, vein that brings blood to the auricle; *B*, auricle; *C*, valves that are forced open by the blood as it passes into the ventricle; *D*, ventricle; *E*, tube through which blood goes to the lungs to be purified

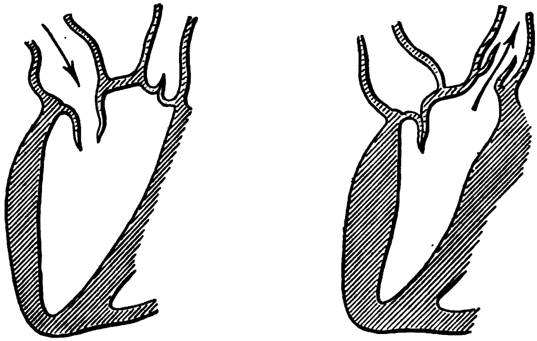
To complete this account, turn to the heart again and remember the following facts about it:

1. The heart is a powerful muscle. It does its work by contracting and relaxing.

2. The heart is made up of two halves; and the wall of muscle between these separate halves is so firmly closed that after birth, and after the heart is in good working order, not a drop of

blood ever passes through it from one side to the other.

3. Each half of the heart has two divisions, the smaller called the auricle, the larger called the ventricle.



TWO VIEWS OF THE SAME VENTRICLE TO SHOW THE VALVES

On the left blood enters; on the right the ventricle contracts and forces the blood onward

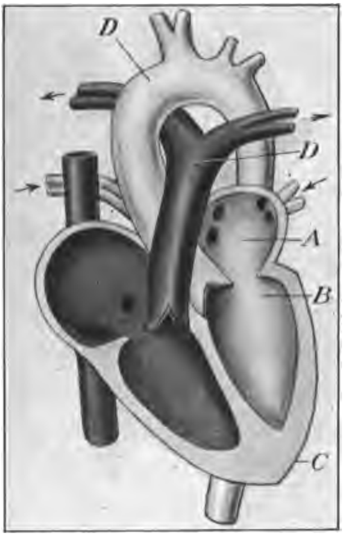
4. Each auricle and each ventricle has its own opening, its own tube for blood, and its own valves to prevent the blood from running the wrong way.

5. The auricle in each half of the heart always receives the blood and sends it into its own ventricle.

6. Each ventricle receives blood from its own auricle and sends it off to its own district of the body.

At this point we reach a most interesting fact about this process of circulation; yet it may be given in a few

easy words. One side of the heart receives blood from the body and sends it to the lungs; the other side of the heart receives blood from the lungs and sends it to the body. We see, then, that one side always deals with pure blood alone, for all that comes to it is fresh from the lungs and is sent onward in the same condition; while the other side deals with impure blood alone, for all that comes to it is from the body after it has been used, and it goes onward to the lungs in that condition to be purified.



THE FOUR CAVITIES OF THE HEART

A, auricle; *B*, ventricle; *C*, outline of the heart; *D*, *D*, blood vessels

The dark side receives impure blood from the body and sends it to the lungs; the light side receives pure blood from the lungs and sends it to the body

Thus the entire blood supply of the body, on each journey round, passes through both sides of the heart and through the lungs before it goes back to nourish the body. This was Harvey's great discovery about the circulation of the blood. Even for him, however, there was a mystery which the microscope alone could solve. The next chapter will speak about it.

CHAPTER XI

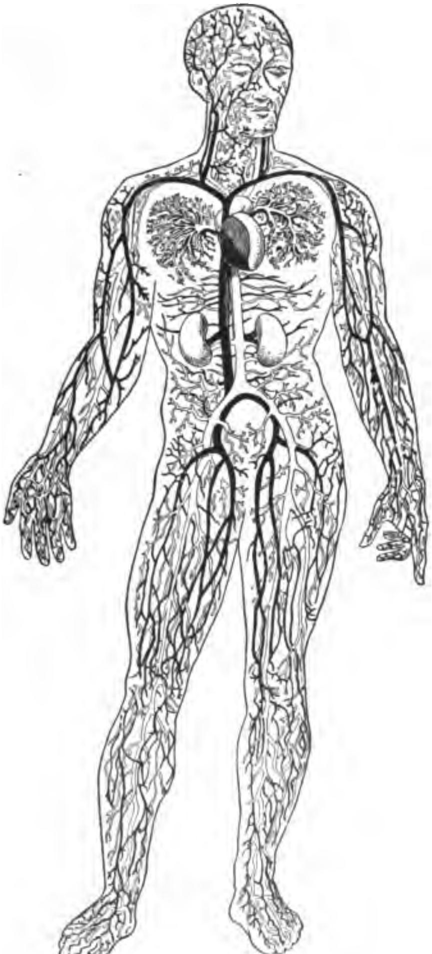
TO THE CAPILLARIES AND BACK

To complete the proof about blood which makes its regular journey from the heart round the body and back again, scientists have the testimony of the blood itself. They have taken a syringe as slender as a needle, and by its use have pricked some harmless chemical into a vein on one side of the body of a horse or of a man. They have then examined blood drop by drop from the corresponding vein on the opposite side of the body until the same chemical has appeared there.

By comparing the time when the substance was put in, with the time when they find it again, they know how long it takes for blood to make the entire circuit of the body. The following table gives results:

For a horse, twenty-five seconds.
For a full-grown man, twenty-three seconds.
For a child of fourteen, eighteen seconds.
For a child of three, fifteen seconds.

Evidently each set of tubes and each heart does its work more or less rapidly, according to the distance which the blood has to travel. But for each one of us the road which the blood takes is ever the same. The

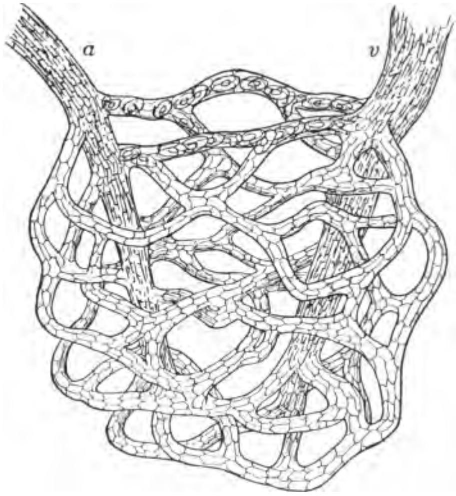


VEINS AND ARTERIES

Black tubes represent veins through which impure blood goes to the right side of the heart from all parts of the body; light-colored tubes represent arteries through which pure blood from the left side of the heart goes to all parts of the body. Notice that the large tubes of each kind lie near one another

steps of its progress are veins, heart, lungs, heart, arteries, veins. When the chemical is found it is on its return trip to the heart.

Even this experiment does not, however, show how the blood gets across from the arteries to the veins for its journey back. Harvey himself was not sure about this, for he had no microscope. But when the microscope came with its revelations, doubts and questions were cleared away. Instead of blood spread about everywhere among the muscles under the skin between the arteries and the veins, there was found to be no blood anywhere outside of the tubes. Moreover, each drop of blood was found to be a part of the ceaseless stream which flows through tubes that divide and subdivide until they are too small for the unaided eye to see, then unite and continue to unite until they are again large enough to be seen.



Union of Arteries and Veins

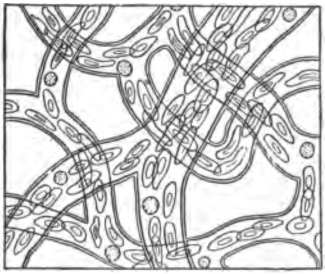
a, artery; *v*, vein. A network of capillaries joins them

From the heart and back again, all the blood of the body is seen to be closely inclosed in these larger and smaller tubes. This is what the microscope shows. And the sight of its progress through the tubes must have thrilled those who watched it for the first time.

One early scientist used his crude microscope on the tail of a tadpole. He had already discovered the corpuscles of the blood, which we shall study soon; and he saw these separate "blood globules," as he called them, moving after each other in single file through the narrowest of the tubes. Sometimes they moved in faster, sometimes in slower, procession; and sometimes they were even bent over and pressed out of shape as they were forced through the narrowest places. He grew enthusiastic over what he saw, and wrote a glowing account of it over two hundred years ago:

> The motion of the blood in these tadpoles exceeds all the rest of small animals and fish I have ever seen; nay this pleasure has ofttimes been so recreating to me that I do not believe that all the pleasures of fountains and waterworks, either natural or made by art, could have pleased my sight so well. And now at last I spied a small artery, that notwithstanding it is so small that, I judge, but one small red globule of blood could pass through it, . . . yet, what was most remarkable was to see the manifold small arteries that came forth from the great one, and which were spread into several branches, and turning, came into one again, and were reunited, that at last they did pour out the blood again into the great vein; this last was a sight that would amaze any eye that was greedy of knowledge.

From what he saw, and from what the microscope may show us, too, we find it easy to understand that every slash and wound of the body cuts through a mesh of lace work more delicate than the finest lace ever made by the hand of man; we see that each thread of this lace is a tube doing faithful duty in carrying blood to remote regions of the body, and that everywhere there is blood simply because everywhere there is the same intricate interlacing of these marvelous tubes. Their name *capillary* means "hairlike." Yet the microscope shows how much smaller they sometimes are than any human hair, however soft and fine.

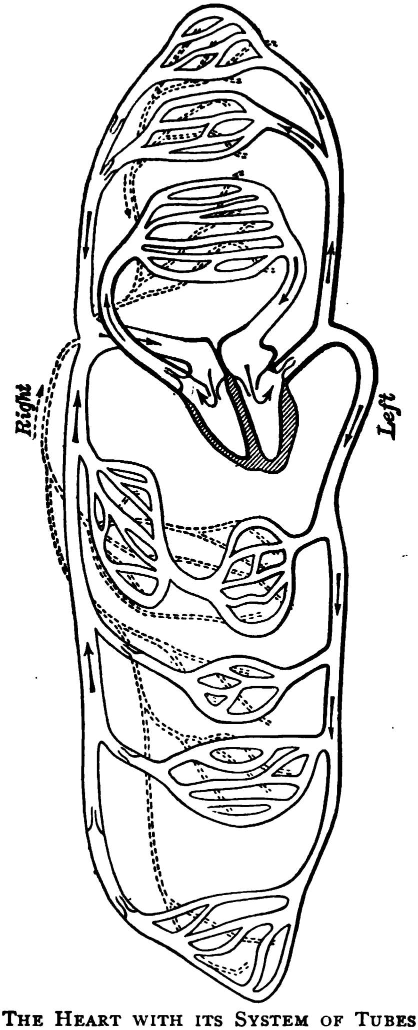


Corpuscles in the Capillaries of a Frog's Foot

By careful calculation it has been found that fifteen hundred capillaries would have to be laid side by side to cover a surface an inch wide.

As a rule, the amount of blood which is inclosed in this system of tubes which includes heart, arteries, capillaries, and veins, is about one thirteenth the weight of the person. We may then calculate our own supply of blood by our own weight.

So much blood does it take to keep the blood vessels and the heart as full as they need to be. The truth, however, is that being elastic they could at any time



THE HEART WITH ITS SYSTEM OF TUBES

Arrows show the direction in which the blood flows. Follow its course from the body into the right side of the heart; from there to the lungs; thence to the left side of the heart and out to the body again. Each cluster of tubes shows in a rough way where some organ of the body is located

hold more than is now in them; and that at any time also they could get along very well with rather less than they now carry.

In former times men sometimes died for no other reason than that they lost so much blood from wounds of one sort or another that the sides of veins and capillaries collapsed, and the heart had to stop work because there was too little blood left in the body to be pumped round. It was therefore a great discovery when men found that the heart is quite as willing to pump warm salt water out into arteries and capillaries as to send warm blood to the same places. Nowadays, therefore, when a man is losing much blood through an operation or through an accidental wound, a surgeon, working as fast as he can, pumps salt water into the veins to replace the blood. This water is carried on round the circuit as swiftly as if it were the richest blood, the pumping of the heart continues, and a life is saved.

No one dreams for a moment that salt water can take the place of blood day in and day out for many days continuously, but all know that it may be depended on for a season. It keeps the veins filled and the heart in action while the proper sort of blood is being manufactured by the body itself.

In a way we might suppose that, whether water is mixed with it or not, the blood of the body is spread out in equal quantities everywhere, being regulated by the

size of the tubes which carry it here and there. The truth is, however, that standing over the blood supply is the never-failing fact that exercise regulates the amount which goes here and there; that is, what we do always settles the question as to where the blood shall go. For the normal, healthy person this law never varies. It may be stated in a few words: *That part of the body which is exercised the most gets the most blood; that part which is exercised the least gets the least blood.*

The next chapter will show what it means to the body when this law is remembered or forgotten, and what the nature of the blood is, that it should be so greatly needed here and there.

CHAPTER XII

BLOOD INSIDE AND OUTSIDE THE TUBES

When you take your morning bath why do you use cold water, a rough wash cloth, and a towel rougher yet? Why do you work fast and rub hard? For the simple reason that you wish to draw more blood to your skin capillaries, and the pink color shows how well you have succeeded.

I have a frail friend with blood vessels so lifeless that her skin is about as pale after exercise as before it. The other day, however, she felt encouraged. "An unusual thing happened this morning," she said; "I managed to get some color into my chest when I rubbed it. I have n't been able to do that before for years." She knew that active movement of the blood through the blood vessels is one of the important advantages of exercise. To understand this more definitely, examine the blood itself. Drops drawn from your own body will meet the need perfectly. To secure them, tie a string round the last joint of a finger on your left hand. This leaves your right hand free for whatever it needs to do. Bend the tied finger over to increase the pressure of the blood in its capillaries. Take the finest needle you have, hold it in a candle or a

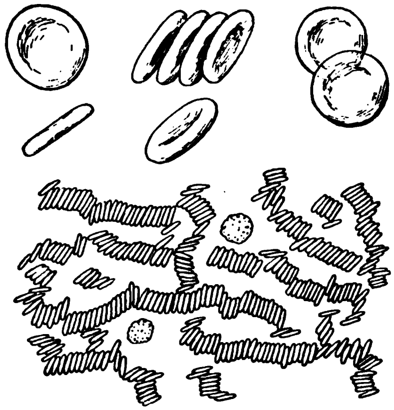
lamp flame for a moment to rid it of microbes, then stick the point of it quickly into the dark red end of the finger. So much blood has been held back that you will barely feel the prick. Nevertheless, a good-sized drop will ooze through and be ready for immediate use.

To get this blood you have torn open the sides of several capillaries smaller than the needle; but they will repair themselves in time, and just at present you have more need of that red drop outside of your body than inside of it. Have a piece of clean glass ready and jostle the drop of blood down upon it. Raise the glass, hold it over something white, and notice the color. You will see that it has a yellow tinge.

PREPARED TO DRAW A DROP OF BLOOD

Now break through a few more capillaries with your needle; draw another drop of blood; put it also on the glass, and leave it there for five or six minutes. Look at it now and you will find that it has turned itself into jelly. Set a tumbler over it and let it remain there undisturbed for half an hour or so. At the end of that time you will see a bit of red substance floating in a small drop of liquid which is almost colorless.

Look back at the finger you pricked, and, if you did not wipe it off clean after you pricked it last, you will see that there, too, a remnant of the blood has hardened round the edges of the tiny wound. This will remind you of the statement so often made, that the best healer for a wound is the blood which oozes through it. We clean a wound thoroughly, we pull the edges towards each other, we even sew them together sometimes, and the blood which continues to ooze from the capillaries hardens on the edges of the wound. We are careful to leave it there undisturbed, for we know that it closes the break better than any kind of plaster, and that the work of knitting these separated edges together goes on best under the crust of hardening blood.



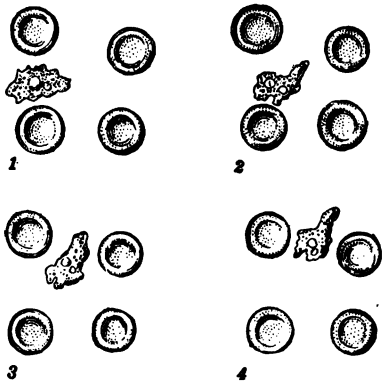
CORPUSCLES SEEN BY THE AID OF A MICROSCOPE

A few red ones are highly magnified. Those that are less magnified show how corpuscles stick together after blood is drawn from the body. Two white corpuscles are given

If we could add the use of a good microscope to our experiments, and if we knew just how to use it for such close investigations, we should draw a third drop of blood, put it under the microscope, and learn a number of startling facts about its composition. We should then

recognize it as a liquid with multitudes of small red and white objects floating in it. Blood is indeed a mixture of three things:

1. Red objects called red corpuscles. There are something like two hundred million of these in each drop of healthy blood. Imagine then their size! Each is round and flat and has a concave center. Its shape is such as you would get by taking a wax marble and mashing it between the thumb and finger. Pressed in this way, the center is thinner than the edges. So is it with every red corpuscle. Nevertheless, these microscopic disks are the important oxygen carriers of the body, and they never leave the blood tubes unless these tubes themselves are crushed or cut or forced to leak through accident or disease.



Red and White Corpuscles

Four different shapes and four positions taken by the same white corpuscle

2. The liquid part called plasma. This is quite transparent and almost colorless. A little over one half of each quart of blood is plasma; the rest is the corpuscles.

3. Colorless objects called white corpuscles. Of these there are only about six hundred thousand to each drop of blood, although the number varies greatly from time to time. They are specks of jelly-like substance that change their shape constantly. They not only travel with the other corpuscles in the plasma, but they also work their way through the walls of the capillaries and wander here and there in the body. They destroy intruding microbes when they find them, and help more than any other part of the blood in healing a wound. Much more is told about these white corpuscles in the last two chapters of this book.

Plasma, red corpuscles, and white corpuscles tell us all that the microscope shows when we use it for the study of blood. But a chemist will take the same blood, will analyze it in his laboratory, and will prove that it is made up of many different substances of which we have not so much as heard the names, — substances needed, however, for the work which each separate part of the body is doing. He will tell us that within this blood is all that is needed for the manufacture of bone and muscle, hair and tendon, tears and fat and finger nails; that it is the source of supply for all that lies under the cover of the skin, the storehouse for more treasures than we have even dreamed about; and that it is easy to enrich or to impoverish the blood by our treatment of the body.

CHAPTER XIII

EXCHANGES ALONG THE TUBES

Even a careless thinker will see that however intricate the lacework of capillaries is, and however closely these small tubes are intertwined with tissues of muscle and gland, still the blood within the tubes is useless to the body unless it can be brought into direct contact with the muscle and gland tissues themselves.

ONE GLASS WITHIN THE OTHER

The smaller glass holds fresh water, the larger holds water and salt

An experiment will make the situation plain and will show what the outcome of it is.

Get from the butcher a piece of fresh animal membrane, — the bladder will do. Fill a small glass with fresh water, tie the membrane tightly over it, set the glass into a much larger one filled with salted water, letting the water cover it, and leave the two tumblers together over night. In the morning take the smaller from the larger, unfasten the membrane, and taste the water which was fresh and sweet the night before. You will find that it is now distinctly salt. Taste

the water in the larger tumbler. You will find that it has grown fresher than when you left it.

In this exchange the salt in the liquid has acted according to a universal law. Salt is indeed one of the many substances which always pass easily back and forth through any moist animal membrane.

Put sugar into one liquid and soda into another; let a membrane be stretched between them, and before long you will have two liquids that have become strangely alike. The different substances in the liquids have changed places through the membrane.

Even gases are subject to the same law. Men who know how to handle such things can put oxygen in one tube and carbon dioxid in another. They can then arrange to separate the gases by a piece of animal membrane stretched between the tubes, and they discover that the two gases refuse to stay apart. Indeed, so much of each finds its way through the partition that soon there is a mixture of the two on either side of the membrane.

Experiments such as these answer the query as to how the body gets what it needs from the blood. Everywhere it is the animal membrane of the tubes themselves which separates the blood within the tubes from a certain other liquid which lies close about them on the outside.

However small and however thin walled the blood vessels may be, there is always this lymph bathing the

outside like a sort of colorless sap in the body, and making its exchanges with the contents of the liquid within the capillaries. Moreover, this lymph which soaks slowly but constantly through every tissue of the body is laden with carbon dioxid which it has received from the tissues of the body. The blood is rich in oxygen, and it is separated from the lymph only by the walls of the capillaries. In view of this, what could be more natural than the thing which comes to pass? These gases in the lymph and in the blood change places with each other as promptly as do the liquid materials which are also in the lymph and in the blood.

It is evident, then, that the lymph is as important to us as is the blood itself. In fact, the two must always travel side by side. They are indispensable to each other. Without the one the other is useless. Three statements will show how close the relation is:

1. Blood in the arteries is the result of the food we eat and of the air we breathe. It contains every supply that any part of the body needs for nourishment, for strength, and for growth.

2. Blood in the veins is what is left after the lymph has taken from it the oxygen and other nourishment which the body needs, and given in exchange the carbon dioxid and other waste which must be carried off. In other words, venous blood is rich in waste from the tissues and poor in nourishment for the tissues.

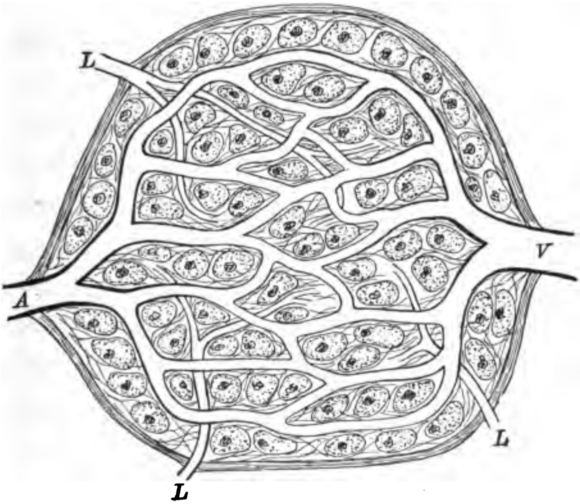
3. Lymph is made up of rich, nourishing plasma from the blood, on its way to the tissues, and of waste material from the body, which will soon pass into the capillaries, be carried onward in the veins, and be disposed of as we shall learn hereafter. Lymph is also the highroad to the blood for many substances that are being manufactured by the different organs of the body. These manufactured articles must find their way into the blood, for only through circulation will they ever be able to reach their destination.

The origin of the lymphatic tubes is strangely interesting for the simple reason that it is so very indefinite. Each seems to begin about as irregularly as a stream gathers water in a swamp.

As we know, blood vessels are a closed system of tubes with a stream of blood sweeping through them endlessly, —going ever round and round, from heart back to heart again. In this great system not even the smallest tube in the remotest region of the body is left with an open mouth. The lymphatic system, however, works on quite a different basis. Here the vast multitudes of the smallest tubes seem to be really little more than open mouths into which liquid is gradually making its way. Bear this in mind while the facts are given as definite statements:

1. Each blood vessel of the body makes its way through a mesh work of tissues.

2. Everywhere among these intertwined tissues there is a colorless liquid called lymph. The capillaries of the blood are surrounded by this lymph even as grass and weeds are surrounded by water in a swamp. Lymph looks like plasma of the blood.



A CLUSTER OF TUBES

Look for those with open mouths: *A*, artery; *V*, vein; *L*, *L*, *L*, lymphatics

3. Lymph and plasma are constantly making exchanges through the walls of the tubes of the blood vessels.

4. Plasma receives from the lymph all that the body is through with — all that should go on in the blood and be disposed of elsewhere.

5. Lymph receives from the plasma all the nourishment which the tissues need.

6. Opening away from the loose fibers through which the blood vessels run, and in which all this exchange is going on, there are other tubes about as small as the capillaries; and into the open mouths of these tubes the lymph from the tissues gradually makes its way.

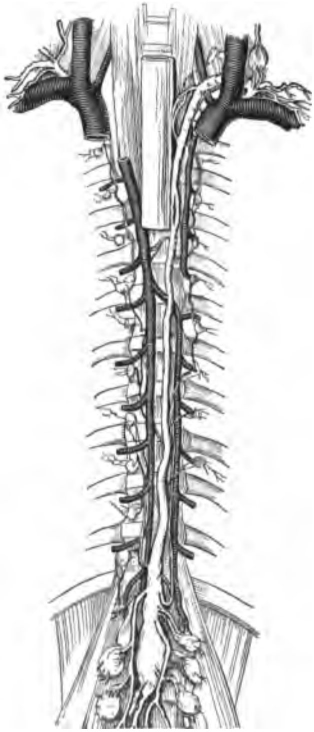
Lymphatics of the Hand

Smaller tubes lie near the surface, larger ones lie deeper

7. Vigorous exercise hastens the flow of lymph no less than of blood, and the tissues are benefited thereby.

8. From start to finish the lymphatic tubes progress from smaller to larger, as do those of the veins. They are also provided with inside pockets quite like those of the veins. These pocket valves keep the lymph from moving backwards and help to send it constantly onward, that it may at last mingle with the great stream of blood that goes to the heart.

9. This progress from smaller to larger tubes continues until all the lymph of the body finds its way through two large lymph tubes, one on each side of the neck. These empty into two large veins, and thenceforward lymph and blood go on their way together to the heart. The lymph, with all it has gathered, has now entered the circulatory system, and thus the contribution from the many different organs of the body will be distributed by means of the blood. The movement of this fluid continues during life, for the lymph vessels and lymph spaces can never be empty so long as the organs of the body are at work.



VEINS AND LYMPH TUBES
The lymph tubes are white and are seen to empty into the large veins

A special point to remember is that blood vessels and the tissues are as much better off when fresh lymph surrounds them as are fish when they are in fresh water.

CHAPTER XIV

ALCOHOL AND CIRCULATION

A man is sometimes so sensitive about the dull red end of his nose that he is ready to welcome almost any device which may rid him of it. Perhaps he knows and

PRICKING THE CAPILLARIES

By electricity through the point of a needle many capillaries are destroyed; after that the man is cured of his red nose

(Copied from the *Literary Digest*)

perhaps he does not know that the reason for the color is the condition of his capillaries. Each smallest tube in the special spot is indeed overcharged with blood; and

in so far as a nose is bright red or dull red are we ourselves able to judge as to whether or not the capillaries are particularly distended just there.

Red eyelids and a pink nose tell plain facts about the state of the capillaries in those particular regions. But in the matter of general health, the mere fact that a man has a red nose signifies very little. Many a hearty sea captain has carried such a nose with him through half a century of life. He has lived to be eighty years old or older, and the shade of his sunburned nose has made him neither more nor less healthy than he otherwise would have been.

Sometimes, however, the color of a man's nose is a sign of general internal conditions. It may show that the capillaries throughout his body are loaded with slow-moving blood; and this condition of the capillaries throws a flood of light on the sort of work which the heart itself is doing.

Judging by facts which we have already learned, three points are clear:

1. Slow-moving blood is more impure than that which moves faster; for this reason such blood is always a disadvantage to any part of the body in which it tarries.

2. The mere fact that blood is moving fast shows that impurities are being hastened out of the way and that fresh material is being supplied to lymph and tissue.

3. The blood vessels must always be in a healthy, vigorous, elastic condition if the best exchanges are to be made through their walls.

In view of these statements we are ready to understand a set of scientific discoveries about circulation which have been made during the past few years. It appears that for many previous years educated doctors and ignorant men alike were united in the conviction that alcohol was a genuine help to the vigor of the circulation. Thousands of men thought they had proved this by personal experience. At different times, and in different places, they had taken alcohol in large doses or in small doses as they chose, and after the drinking they had tested their hearts and knew by the count of the pulse that the number of heart beats had increased. They felt the blood bounding faster through their veins, and it was most natural for them to believe that the alcohol which they had taken had strengthened the heart, even as food strengthens the body.

In time, however, an instrument was invented which measured the strength of each heart beat. This instrument is in wide use to-day, because doctors find that they can judge in a general way as to whether a man is well or not by the vigor or the languor with which his heart does its work.

And now for the surprise which overtook doctors and scientists alike. They took alcohol themselves;

they gave it to their friends and their patients; they studied the heart and found that its throbs had increased in number. But when they also used the instrument — the sphygmograph — they were surprised to see that the heart was not putting as much power into each stroke now as it did before the alcohol was taken.

THE SPHYGMOGRAPH IN PLACE

By the use of this instrument men learn facts about the way the heart and the arteries are working

Over and over again the tests were made, and always with the same result. Each trial showed that although the heart was now pumping faster than usual, it was nevertheless doing its work with less vigor. It was using less force for the increased number of strokes than it used for the smaller number made before alcohol had been added to the blood.

Testimony of this sort put a new color on the practice of using alcohol when the heart needs to be strengthened.

Doctors in every land had to yield to the evidence of their senses. They had to believe that, instead of giving strength, alcohol actually robs the heart of a part of the strength which it had before the alcohol was taken.

This was a difficult doctrine to accept, and question and investigation continued to pursue each other in quick succession until at last there was no further doubt about it. To-day the facts of the case are accepted by all persons except those who are not up to date in the matter. I give a few of the most important points:

1. Healthy tubes that carry blood are elastic. They stretch out when blood is pumped into them by the heart, and they contract firmly again as they send the blood onward.

2. The first effect of alcohol in the body is to paralyze in a very slight way every tube that has anything to do with carrying blood hither and thither.

3. Because the tubes are slightly paralyzed they are more relaxed than formerly. They contract less. They therefore offer less resistance to the blood that is pumped into them. After they are full they stay relaxed, and do not have the elastic power to pull themselves firmly into shape again.

4. The heart is also slightly paralyzed by the alcohol. Still those countless relaxed tubes offer so

little resistance that the heart pumps the blood into them with less effort than formerly, and, as a result, contracts more frequently.

Thus far, however, no harm appears. The capillaries are full of blood; the man feels the warmer for it, and his heart is beating a trifle faster than usual. That is all. But now begins the chapter of damages and calamities.

During the time that the heart itself is weakened, it cannot put force enough into each stroke to drive the blood on in spite of the relaxed state of the walls of the tubes. Various results are now inevitable. Blood moves more slowly through the tubes; it is slow in carrying away broken-down tissue from the lymph; it is slow in bringing fresh nourishment for the rebuilding of the tissues.

In the meantime, if alcohol continues to be taken, the capillaries may be kept stretched so long as to lose all power to contract. If this is persisted in, the walls themselves end by becoming thicker and stiffer. The work of exchange which should go on at a rapid pace through them is thus interfered with, and the health of the drinker suffers in numerous ways.

This is no fancy picture. It is simply the history of circulation in such persons as are ignorant enough to be willing to rob themselves of the work which their blood and their blood vessels should do for them.

The most alarming side of the affair, however, is in connection with what happens to the heart. Because

this tireless pump is weaker than it was, it also becomes stretched; and as it cannot do full work, it lacks the exercise which would keep it in vigorous health. It grows flabby, as does an unused arm. Fat gathers not only between the fibers but also within the separate fibers. In this latter case fat takes the place of tissue

TWO HEARTS SIDE BY SIDE

On the left the heart is normal, on the right it is enlarged and weakened by fat

(Copied from *Alcohol and the Human Body*, by Horsley and Sturge)

itself, and then occurs what is called fatty degeneration of the heart, — a most serious condition. For a heart of this sort is too weak to send blood onward as rapidly as it should go. This means that circulation throughout the entire body is hindered, and that each great organ suffers for lack of what it should get through fresh supplies of blood. Evidently then he who owns a fatty heart,

weakened from any cause, is far less sure of continued life than he might have been. Since he secured this condition through ignorance, he is not to blame. But sad as is the fact, ignorance never saves men from the results of their ignorance.

Why do surgeons dread to do anything for the man who uses alcohol? Because they know only too well that the power of his heart and the elasticity of his arteries have been reduced. They are afraid that his heart may not rally after they have done what cutting is necessary. In writing of this danger, Sir Frederick Treves says:

> Having spent the greater part of my life in operating, I can assure you that there are some patients that I don't mind operating upon and some that I do; but the person of all others that I dread to see enter the operating theater is the drinker. He is the most dangerous feature in connection with the surgical life.

It is because of this constant state of relaxed capillaries that the nose of the drinker stays red. In his case the nose is frequently a reliable sign of internal conditions.

CHAPTER XV

AS WE GROW BREATHLESS

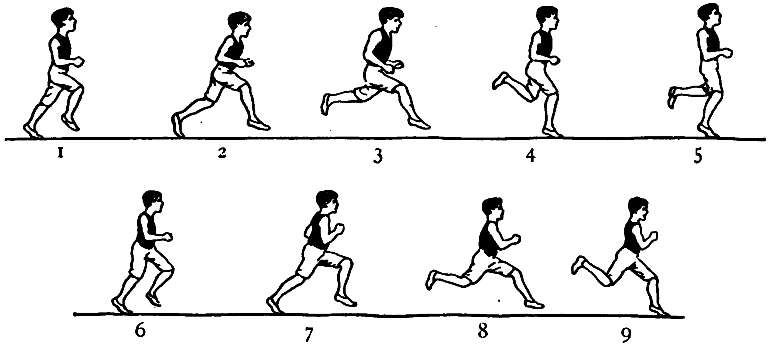
If you were ever thoroughly out of breath, recall the sensations you had at the time. Perhaps you were trying to catch a train; perhaps you were running in a relay race. In either case you felt that you must reach the goal at all hazards, and you ran as you had never run before.

RUNNING AS FAST AS POSSIBLE

But think of the discomfort of it! Since your legs were young and strong you thought nothing about your muscles but simply used them hard. You ran fast. Your breath came and went freely, and during the first few moments you drew deep, long breaths of equal length. Soon, however, you found that each breath was shorter than the last; also that they came and went in quicker succession. You began to be uncomfortable. There was a tight feeling within you, as if an iron band were closing itself about

your chest; as if it prevented you from expanding your lungs to their full size. You wondered how much longer you could keep it up.

But why were you breathless? To answer the question, follow once more the condition of muscle and bone, tendon and heart, lungs and blood vessels, while you were running. Think for a moment of your unelastic



NINE VIEWS OF THE SAME MAN AS HE RAN

A different set of muscles is at work in each position, so that altogether many muscles are used in running

(After Schmidt)

tendons as they stayed firmly gripped to their bone attachments. Remember how each one of multitudes of muscles, large and small, shortened and lengthened as by means of their tendons they pulled those leg bones of yours up and down and kept them at work. Remember that neither arms nor head nor any other part of your body was quiet as you ran, but that every

muscle seemed to work hard in keeping time and step with the movement of the legs. Remember that such violent action as this means that changes are going on in the substance of the living tissue which is exercised, that these changes involve the giving off of unusual quantities of carbon dioxid, that oxygen is needed by the working fibers, and that in order to supply the oxygen and to carry off the carbon dioxid, fresh streams of blood must be hastened to the active muscles with ever-increasing speed. The most immediate, imperative need of each working fiber is to get rid of the excess of carbon dioxid.

There are three things which bring about such a condition of breathlessness:

1. Exercise violent enough to compel the fibers of the muscles to produce unusual quantities of carbon dioxid. As this gas is produced, oxygen is demanded by the fibers. It is indeed as if they themselves were breathing.

2. The activity of the chest walls as they expel the carbon dioxid from the air sacs of the lungs and replace it with air containing oxygen.

3. The rapid work of the heart as it receives larger amounts of impure blood than usual through the veins and sends arterial blood to the tissues to carry oxygen and to bring away carbon dioxid. To a large extent it is this forced work of the heart that explains the feeling of breathlessness.

We were speaking of this matter the other day, and my friend, who teaches physiology, said:

People used to say that a man was breathless because there was more carbon dioxid in his blood than he could expel through his lungs. But we know better now. We know that it is n't so much the carbon dioxid — although of course that has to be driven off — as it is the overtaxed heart that makes us breathless.

Boys come to me for examination, and I tell them that the heart gets tired from overwork, just as the biceps does, and that it is quite as possible to strengthen the heart by training as to strengthen the biceps. At first I put the boys on easy exercises that tax the heart but little; then day by day I give what is harder until, almost before they know it, those boys have developed hearts that are strong enough to do good hard work without making them breathless.

The recognized fact is that we grow breathless in proportion to the force which we put into any exercise in a given length of time; that is, the faster we do the same thing, the more quickly will breathlessness overtake us. It is easy, therefore, to understand an opposite condition, and to believe that the quieter we are, the less oxygen the tissues will use and the less carbon dioxid the body will have to get rid of.

The following figures show the amounts of carbon dioxid which a man gives off while sleeping, sitting, or running for a given length of time:

While sleeping	.035 gram
While sitting	.060 "
While running	.165 "

Men have killed animals after a long hunt and have found the blood of the arteries so changed in color that it looked like blood from the veins. It was dark and impure because it held an oversupply of carbon dioxid and had lost most of the oxygen.

When we are breathless most of the trouble is due to the fact that the heart is overtaxed by the large quantity of blood sent to it from the hard-working muscles to be forwarded to the lungs to be purified of its carbon dioxid, while at the same time the lungs are also overtaxed by their unusual work.

Those who train for athletic sports learn to keep the balance of the gases in their blood. They know how to manage their running and the work of heart and lungs in such a way that neither will be overtaxed until the end is near. They are willing to be breathless at the very last because they are soon to stop running and catch their breath again. But to get breathless at the beginning of the race means defeat.

The same is true in horseracing. No good jockey lets his horse get out of breath until the last part of the race. At that time, however, the horse is urged to work the muscles of his legs as hard and as fast as possible. It is safe to do this now, for as soon as he reaches the goal his muscles will stop producing such quantities of carbon dioxid and his heart will cease to be overtaxed by its work of pumping this impure blood to the lungs to be purified.

CHAPTER XVI

WHERE BLOOD CHANGES COLOR

Place one hand lightly on your chest; place the other on your back between the shoulder blades; inhale slowly until your lungs are full, then exhale slowly until they seem empty. While you do this notice that the breastbone rises, and that the front and rear walls of your chest are forced gradually farther apart.

MEASURED BY THE DOCTOR

While you take another long breath and send it out again stand with your hands resting lightly on each side of the body just over your lower ribs. Notice that it is expansion sideways this time; you also see that the capacity of your chest has increased greatly.

Take a tape measure and get the girth of your chest after you have exhaled all you can, and again after you have drawn in as large a supply of air as your lungs will hold. Learn from these tests that the size of your chest can be increased and diminished at will, and that its size can be increased permanently by frequent exercise of

this kind. To prove this in your own case, measure your chest to-day; then for two months take fifteen deep, full breaths three times a day. With each breath expand your lungs as fully as you can without really straining them. At the end of the two months measure yourself again and you will find that your chest measure has increased. From this you have the right to conclude that your lungs also are larger.

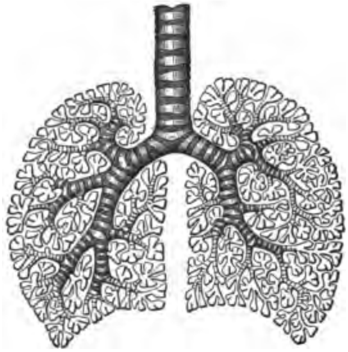
WITH HIS CHEST EXPANDED

We often talk of the lungs as if they were a pair of big bags tucked in under the ribs somewhere, waiting to swell out or to sink in according as we use them. In a way the notion of the bag is rather correct, except that instead of two bags, one on each side, we must think of thousands upon thousands of microscopic bags called air sacs. We must recall what we learned in *Good Health*, and think of each one of these sacs as the expanded tip of a tiny tube that ends in it. We must remember that the tubes themselves are the small twigs of larger tube branches, and that within the

A HOLLOW CHEST

large chamber which the ribs make we have two sets of these branching tubes ending in air sacs. Each set is called a lung. The heart lies between the right and left lungs, and is a trifle more on the left than on the right side.

For the sake of saving time and space a few facts, new and old, must be given under numbered headings. They show how the lungs help us throughout our lives:



TUBES AND AIR SACS OF THE LUNGS

1. Blood that enters the lungs is so dark and so well laden with carbon dioxid — although there is also some oxygen in it — that we call it impure. Blood that leaves the lungs is so well loaded with oxygen that it has gained a bright scarlet color, and we call it pure, as indeed it is. Even in pure arterial blood, however, there is some carbon dioxid.

2. Lungs are at work not because they themselves need air, but because they serve as a storehouse and a place where oxygen and carbon dioxid may change places. Such a central exchange is needed because, as we know, here and there over the entire body each smallest tissue is in need of oxygen and must be relieved of its carbon dioxid. It is in the lungs

that blood unloads itself of most of its carbon dioxid, loads itself up with oxygen, and streams off to some distant destination. Breathing, then, is mainly for the benefit of the tissues of the body, not for the sake of the lungs themselves.

3. All the blood of the body comes to the lungs and goes away again once every twenty-three seconds. While it passes through the lungs it does not leave the capillaries, but the capillaries themselves are so closely intertwined with the air sacs that the two cannot be separated. And while they lie thus near together, with capillaries close about the air sacs, rapid exchanges are taking place. Oxygen mixed with the other gases of the air is on one side of the animal membrane of the air sac; carbon dioxid, with a little oxygen, is in the blood on the other side of the membrane within the capillaries. And as the gases are side by side, two of them — the oxygen and the carbon dioxid — change places without delay. Oxygen enters the blood from the air sac; carbon dioxid enters the air sac from the blood; the red corpuscle carriers are loaded in the twinkling of an eye, and hasten off to unload where their cargo is called for. In the meantime, however, the large supply of carbon dioxid is as unwelcome in the air sac as it is everywhere else in the body. It is therefore expelled as promptly as possible by an outgoing breath.

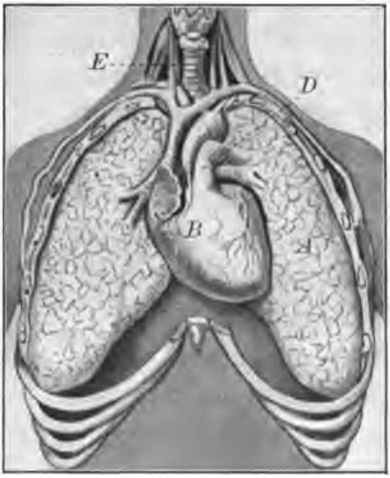
In view of these three important facts it is quite evident that large, healthy lungs will be invaluable to any one who wishes to take vigorous exercise, and that, on the other hand, this exercise itself is the very best thing that can be done to develop the lungs.

A man is always glad when his chest measure seems to show that he has large lung capacity; and many a man with a narrow chest has tried to enlarge his lungs by raising his ribs, by walking with chest forward, by taking exercises which have given him strong arms, a strong back, and firm muscles across the chest. In so far as these exercises made him breathe deeply he helped himself, but unless he held this fact in mind he may not have gained so much as he hoped, for the surest way to increase the size of the lungs is by exercising the breathing muscles and by stretching the air sacs themselves. The entire group of sacs should often be compelled to expand more fully than they naturally do in the course of regular daily breathing; and the best way to expand them is not by standing still and taking deep breaths, but by using large muscles vigorously, thus compelling the lungs to work hard too.

GROUPS OF AIR SACS

Many a sagging chest hides from sight multitudes of inactive air sacs that have never been expanded through hard exercise. Nevertheless, each separate one would

have worked well and would have increased in size if its owner had been intelligent enough to compel it to gain capacity and power through such hard breathing as comes from fast walking, from running or jumping, or from lively games played out of doors.



HEART AND LUNGS IN CLOSE CONNECTION

A, left lung; *B*, heart; *D*, tube through which blood goes to the lungs to be purified; *E*, windpipe through which air goes to the lungs with oxygen for the air sacs

Unless some care is taken, endless numbers of air sacs may stay inactive for weeks together, and end by being a source of danger. Only by the full breath, which is broad as well as deep, does much air get into the upper corners of the lungs, and these air sacs, left inactive, yield quickest to disease microbes when the attack comes. It is indeed just here that tuberculosis most often begins its work. This dread disease makes rapid advance in the lungs of those who have the largest number of unused air sacs.

Even for the sake of future health, then, exercise of the lungs is invaluable. This exercise may be secured in one of two ways:

1. By voluntary full breathing exercises. Ten full breaths taken three times each day will keep the air sacs in active condition. This is much better than nothing.

2. By involuntary full breathing. This may be brought about very quickly by giving vigorous exercise to the large muscles of the body. Running and climbing, skipping rope and dancing, anything that uses large muscles fast will fill the air sacs and keep them in good condition. You may prove this for yourself.

While taking exercise or breathing at any other time, keep in mind the following valuable points learned in *Good Health*:

1. Air enters the lungs through tubes that begin with the nose and end in air sacs.

2. As a rule breathing should be done through the nose and not through the mouth, because the delicate, damp lining of the nose warms the air and cleans it before it reaches the air sacs.

3. It is important to send down well-cleaned air, because the inside lining of each air tube is made of the most delicate membrane and is easily injured. Dust that brings tears to the eyes is even more harmful to the lungs.

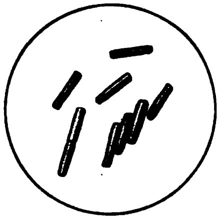
With all these facts before him, let the young person who has a narrow or flat chest set about his own

improvement. Let him apply his knowledge and secure for himself a chest that will be a cause for honest pride. If he wishes to be an athlete, he must not forget that the best developed leg muscles are of little use for running unless the lungs and the heart are able to do their share of the work. For, as some one has said, "We run as much with our lungs and our heart as with our legs."

CHAPTER XVII

THE FOE OF MAN — TUBERCLE BACILLUS

Perhaps no discovery connected with the lungs has ever excited the thinking people of the world quite so much as that of Dr. Robert Koch in 1882. This man was a German scientist; and when he declared that he had found the microbe which kills more human beings each year than any other one disease, the news seemed almost too good to be true.



TUBERCLE BACILLI

Three thousand put end to end will measure one inch

The fact is that, until 1882, no one had ever known how tuberculosis[1] travels, how to prevent it, or how to cure it. Yet on all hands, in all lands, doctors were appalled at the death rate that followed wherever the disease went. By studying the records they saw that, each year, in New York City alone, ten thousand men, women, and children die of tuberculosis; that in the United States as a whole five hundred thousand people are constantly ill with it; that one hundred and fifty thousand of this number die each year of tuberculosis, and that the ranks are

[1] Tuberculosis of the lungs is called consumption.

quickly refilled by those who have been well previously, but who in some mysterious way have been stricken with the disease. Doctors also realize that in the world itself about one million people are killed by tubercle bacilli each year, a number larger than the total of those who are slain in the battles of the world for a century.

Heretofore, in every land, the saddest part of the situation has been that when a person found he had tuberculosis he felt helpless about it. He thought the chances were all against his getting well again. He even thought there was little to do but to get ready to die. Imagine then the great hope that sprang up everywhere when Dr. Koch announced that he knew where tuberculosis came from and how men might escape it. He said he had made the discovery by the use of his microscope, and that what he found was a living and growing thing. He gave the microbe a name, tubercle bacillus; studied its size and shape; noticed its habits; watched it multiply; learned how it may be conquered in the human body, and also saw what conditions favor its rapid growth. Knowing as he did that each one of his discoveries would help save the lives of men, he published his conclusions promptly. Here are a few of his facts packed closely together:

1. Each separate bacillus is a separate plant.
2. Each is small and slender like a tiny rod.

3. Three thousand of these microbes put end to end will measure one inch.

4. Each multiplies by dividing.

5. The only place where they can multiply is in the bodies of men and animals, or in laboratories where scientists raise them.

6. After they leave the body they live, but apparently they cannot multiply.

7. They live best in damp, dark places.

8. In such places they live anywhere from a few weeks to two years.

9. Bright sunshine kills them in a few hours.

10. Boiling kills them at once.

11. Cold does them no harm.

12. They can live and float about in the driest dust.

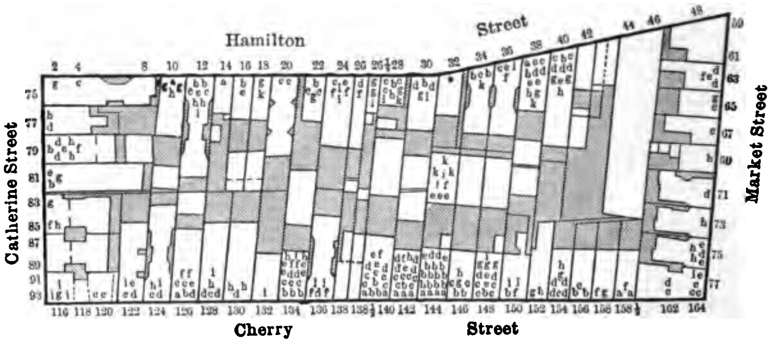
13. They may give tuberculosis to any part of the body.

14. They give it to the lungs most often.

15. Tuberculosis of the lungs is what we call consumption.

The discovery of all these facts, one by one, was exciting to every doctor, every scientist, and every consumptive who heard about them; for each one knew that a turning point had come in the history of the disease, and that there was hope now for thousands of people who were hopeless before.

It was also clear that, from the highest to the lowest, from the richest to the poorest, from the wisest to the most ignorant, all sorts of people were exposing others to the disease every day, and that each one was blameless; for until Koch's great discovery no one knew the facts about the tubercle bacillus. Now, however, various



"LUNG BLOCK"

The shaded parts show courts and air shafts. Each letter stands for one case of consumption reported since 1894. All the "a's" belong to 1894, the "b's" to 1895, the "c's" to 1896, etc., up to 1903

earnest men and women learned these facts by heart and studied the history of tuberculosis both in the country and in the city.

They found that, as a rule, there is more consumption in places where people are crowded together in dark rooms than anywhere else, and that even here there is the greatest difference in special houses and special rooms. This was the case with what is called "Lung Block"

in New York City. Here during nine years two hundred and sixty-five cases were reported to the health department, and very many more were unreported. Single rooms also told their sad stories.

Mr. Ernest Poole, who has studied the subject thoroughly, gives the report of one of these rooms for seven years. He says it is on the third floor, looking down into a court, and that in it people died of consumption steadily, one after the other.

1. A blind Scotchman, in 1894, had consumption, went to the hospital, and died there.
2. His daughter had consumption and died.
3. One year later a Jew was taken ill there and died in the summer.
4. A German woman took the disease, died, and left her husband there.
5. An Irishman was the victim. He worked hard, caught the disease, fought against it bravely, but died in 1901.

Another house on the East Side of the city has dark halls, where you must grope your way about, seventy small rooms, with almost no outside air and light, and an air shaft partly filled with rubbish and filth. One hundred and fifty people live in that house and die fast of consumption. In the middle apartment, on the second floor, five families were lodged, one after the other, for four years. One of the first family died, two from the

second, and one from the third, while two members of the fourth family died in the hospital after leaving the place.

At the last report a fifth family of eight persons was living in the same rooms, and it is hardly to be supposed that they will all escape the fate of the others; yet after they have lived there for a while, after one or two of them have died there of consumption and the rest of the family have been frightened away, other people will visit the rooms. They will look about and will notice nothing more objectionable than darkness, dirt, and close air. They will discover no microbes, will suspect nothing, will agree to pay the rent, and will come to the rooms to live; they will not know that instead of long life there the chances are that some of them have come to those rooms to die and not to live.

Now how does it happen that, over and over again, after there has been one death from consumption in a house, other cases are almost sure to follow, and then still others again, for years and years afterwards?

The whole explanation is in the power of the microbe, the tubercle bacillus itself. Those who examine the room can, of course, see no sign of these microbes, yet there may be millions of them in the dust on every side. They may be lodged in the cracks of the floor, may be clinging to the walls and the ceiling, or may be hidden in the folds of the curtains. Often all they need is to be stirred up by a broom that has not been dampened, or

to be flourished about with a feather duster; for they are thus tossed into the air and are ready to do their mischief.

As we learned in *Good Health*, dry dusting is a calamity to those who live in any house, for it simply lifts the microbes from the spot where they are quiet and harmless, and scatters them in the air, where, until they settle again, they threaten all who breathe it. Damp dusters are therefore necessary, and wet sawdust or torn-up damp paper scattered on the floor before sweeping will keep down these microbes.

It is not in the city alone that these microbes are found, but any town or country home is able to protect them if they are once scattered in it, while deep velvet and plush are fine shelters for them. After microbes once reach a room, if care is not taken to disinfect it and kill them they will live there for months and even for two years.

The very nature of the microbe explains all this. It has no mind. It makes no plans. It simply lives on when nothing kills it, and multiplies when it finds a comfortable home. Yet it never goes hunting for a home, for it cannot move about on its own account. On the contrary, if it is in the air the wind may drive it anywhere, and it will stay where it is tossed until something starts it moving again. It is so small that a man may breathe it with the air. It may escape all the cilia and

the mucus of the air passages and safely reach the spot where it grows the best, the lungs of a human being.

Here everything is favorable. The place is warm and moist, the delicate tissue is good ground to grow in, and the microbe begins to multiply promptly.

Yet there is another side to the situation. The lungs themselves seem to make a protest. They like the microbe no better than a human eye likes a bit of cinder. At once, therefore, certain cells of the lungs hurry to the spot, surround the microbe, and try to build themselves into a wall about it. In a way it is a sort of contest, and at last the multiplying microbes and the cells are bunched together in a hard lump called a tubercle.

Sometimes the cells of the lungs are vigorous enough to fasten the microbes up so securely that they cannot multiply. In this case they become harmless and the man does not have consumption. At other times the microbes prove to be the stronger of the two. The tubercles then increase, the man's lungs gradually become useless, his whole body being also poisoned by the multiplying microbes, and finally he dies.

The danger to other folks comes before that. It seems that as each tubercle grows larger the center of it softens, and the man coughs it up if he can. This is the sputum so full of danger. Often it has a yellow color and is full of the microbes themselves. The worse off a man is, the more he coughs and expectorates; while the more he

expectorates, the more living, dangerous microbes he sends into the world.

Those who know about it say that a man with consumption may expectorate two or three billion tubercle bacilli every twenty-four hours. Such a man may wet his handkerchief with the sputum; he may get it on the sheets and clothing; and there, as anywhere else, it dries, flakes off, flies about, and carries danger.

Instead of tuberculosis of the lungs young children are more apt to have tuberculosis of the bones, which gives them crooked backs and hip disease. This is often cured by skillful doctors.

Fortunately, however, no one inherits any kind of tuberculosis. To be sure, children of consumptive parents often have it, but they have every chance to take it after they are born; for they may live in the same house with their careless, consumptive parents, may touch the same things, breathe the same microbe-laden air every day, and may even creep about on the floor, where dust and microbes are thickest. Worse yet, without intending the slightest harm, those parents may even kiss their children on the lips. They do not know that this should never be done.

With thousands of careless citizens coughing and expectorating every day for months and for years, it is easy to understand how streets and houses, rooms and people, all become infected; for each new case of a person

who is careless with his sputum means more microbes to shift about, and at a moment's notice they are ready to go back into the lungs of any human being who breathes them. After that the vigor of those lungs themselves is the only thing that can save a man.

CHAPTER XVIII

WAR AGAINST THE ENEMY

In 1907 the Maryland Association for the Prevention and Relief of Tuberculosis passed through an exciting campaign. Its rally call was, "Will you help build the fence?" And for twenty-three days this mystic query appeared in large letters on every street car in Baltimore, and on nearly every blank wall; even the ash cans did not escape. At first there was curiosity on the part of those who saw the sign; next came interest; and when the meaning of the question slipped out, when all knew that it meant a "fence" of prevention to protect citizens against consumption, there was such enthusiasm that in less than three weeks ten thousand dollars were raised for the use of the association during 1907.

**WILL YOU
HELP
BUILD THE
FENCE
?**

This then is the sort of warfare that is now going on in Maryland and elsewhere in the world to-day. We know that each year our invisible foe is killing more human beings than have been slain in battle during the past one hundred years. And now that we have actually

found the foe, now that we know both how to kill him and how to protect ourselves from him, we are pledging ourselves to do it. We know that there are just two ways by means of which the world may banish tuberculosis:

1. By destroying the microbes which start the disease.

2. By making human bodies vigorous enough to resist the microbes.

In carrying on the campaign, therefore, the triple motto must be:

1. Tuberculosis is preventable; we will prevent it.
2. Tuberculosis spreads; we will check it.
3. Tuberculosis can be cured; we will cure it.

With this as their motto men and women in all lands have joined hands in a world-wide anti-tuberculosis crusade. They are printing and distributing leaflets by the hundred thousand and the million, for they are determined that those who are well shall know how to protect themselves from the microbes of those who are ill, while at the same time those who are ill shall know enough not to pass their microbes on to others.

The sad fact is that multitudes of people are ignorant both about giving and about taking the disease. Nevertheless it is as true to-day as it ever was that the person who breathes dust loaded with tubercle bacilli is in danger of tuberculosis, and that the only way to escape the danger is to keep the lungs healthy and not to breathe such dust.

Yet how shall we keep from doing this?

Careless people leave their deadly sputum in crowded rooms, cars, theaters, stations, and saloons. It then passes through all the stages of drying, being crushed, turned to powder, and getting into the air; and afterwards, in each of those places, people breathe the air thoughtlessly. In New York City a man breathes anywhere from ten to four hundred microbes a minute, according to the place he is in; and the larger the number the greater the chance that tubercle bacilli are among them.

When, therefore, you see a man expectorate carelessly in public you have a right to say to yourself: "One thing is plain, either that man is absolutely ignorant or absolutely selfish; either he does not know the laws of health, the laws of the microbe, and the laws of the city against spitting, or he is willing to run the risk of giving a deadly disease to his fellow-citizens."

Of course it is true that saliva without tubercle bacilli in it can do no harm; but cities know, as we do, that what a well man does the ill man is sure to do. For this reason laws against spitting cover every citizen, young and old, well or ill. Many cities post their laws in cars, stations, and all public places, and they enforce them or not according to their zeal for the welfare of their citizens. Here is a New York notice:

Spitting on the floor of this car is a misdemeanor. A fine of $500, or imprisonment for one year, or both, may be the punishment therefor.

Some cities are so much in earnest about this matter that men in tall silk hats as well as those in shabby derbies have been fined for breaking the law.

A few years ago no one protested when a man left his saliva on the sidewalk or floor of a car or station. It was so common that almost no one even noticed the spitting. Now, however, the man who spits is seen by a dozen different people at once, and each one looks upon him as either a deserter from the camp of good citizens or as a friend of the enemy.

For his own sake, therefore, as well as for the sake of his city, each loyal citizen should practice the following rules of prevention. By so doing he will prove his loyalty.

1. Never spit in a place where sputum may dry and get into the air.
2. Use paper or cloth and burn the sputum before it dries, or else use a spittoon that has water in it to prevent the microbes from drying and floating around in the air. Such spittoons should be properly cleaned.
3. If there is a persistent cough and a good deal of sputum, tell the doctor about it. He will have the sputum examined.

Every doctor in the land knows how important this last point is, for the secret of curing consumption is to discover it when it first begins, and the only possible way to do this is to examine the sputum for tubercle bacilli.

Tuberculosis of the lungs is really somewhat like a fire in a lumberyard. If the fire is discovered when it first starts, a single pail of water will dash it out; but if it is left until the whole lumberyard is blazing, even the fire department cannot be of any help.

So too with tuberculosis. Three quarters of the cases found early and taken care of are cured, while the cure itself is often as simple as the fire cure, although in the case of consumption four things are needed instead of one:

1. Fresh air from morning until night and from night until morning.
2. Sunshine.
3. Wholesome food, with an abundance of fresh milk and eggs.
4. Rest for body and mind.

If the patient discovers the disease soon after he takes it, and if he can get those four things, he will probably recover; if he cannot get them he will probably die.

Consumptives who are careful about their sputum are not in danger of giving consumption to others. They may live under the same roof with them, work side by side at the same bench, breathe the same air from day to day, and yet, from first to last, if they destroy every drop of their sputum other people are not in danger. As tubercle bacilli never fly away from a damp surface they stay in the throat and air tubes of a consumptive and do

not get into his breath unless he breathes hard or sneezes. If he does either of those things he should hold a cloth before his mouth and burn it immediately, or have it boiled.

Any citizen with a vigorous body is best able to resist every sort of disease microbe. To secure this body let each of us learn to shun what have been called the five tuberculosis D's—dirt, darkness, dampness, dust, and drink. Let us also practice the golden rule of the anti-tuberculosis leagues:

Don't give consumption to others.

Don't let others give consumption to you.

Those who understand tuberculosis best speak very positively about using medicines for it. They say:

1. No medicine has yet been found that will cure consumption.

2. Advertised medicines often contain alcohol, which hastens consumption.

3. No person with consumption can afford to run the risk of taking any advertised medicine.

4. In taking medicine a consumptive should go by the advice of a good doctor.

Then too, from first to last they should seek those four best things,—fresh air, sunshine, wholesome food, and rest. The more successful one is in securing these things the more speedy will recovery be.

In the country as well as in the city men need to know both how to prevent tuberculosis and how to cure it if it

has made a start. The wisest of them will see to it that windows are open in their homes, their shops, and their schoolhouses. They will keep them open by night as well as by day, for they will know that less dust is being stirred up at night and that night air is, therefore, the best air to be had.

FRESH AIR IN A CITY

At the same time they will make sure that their bodies are warmly covered when they sleep in cold rooms full of fresh air. A quick, inexpensive way to get extra covering is to sew newspapers between blankets. Paper does, in fact, keep cold out so well that in some places paper blankets are manufactured, and they can be bought by the dozen for very little money. Keeping warm enough and breathing fresh air must go hand in hand.

In a city even hospitals have trouble in giving a man all the air he needs. Windows are kept open and reclining chairs are put on the roof for certain patients to use. Other patients breathe fresh air even in bed, for the cot itself, with the man on it, is thrust through an open window into the air and sunshine. Other devices help,

A Tent Colony
Air and sunshine to cure consumption

but a sanatorium or a tent in the country is best of all because in such places every needed thing is at hand.

Some consumptives go even farther than tents, and actually sleep out of doors in midwinter.

Dr. Irving Fisher says that he did this when the temperature was ten degrees below zero. He also says that in the winter of 1904, in the Adirondack Cottage Sanatorium, six people slept out doors when the temperature was thirty degrees below zero. They had two or three mattresses under them, warm blankets and comforters

over them, heavy night clothes about them, and also woolen "head gear" with an opening for the nose.

Each person knew that the more fresh air he could get the more chance he had to live. It even seemed as if the colder the air the better he felt.

It is because of these facts that what are called open-air classes are springing up in many places. Those who start the classes know that every chance for life and health is increased for children if those who have been attacked by tubercle bacilli can do their studying out of doors and not within the four walls of a schoolroom.

In this great anti-tuberculosis war, cities are sure to be victorious in the end, but how soon the end will come depends on whether or not the children of the world understand how serious the danger is, and whether or not they are willing to join the forces that fight tuberculosis in every land.

CHAPTER XIX

ADULTERATED ALCOHOL AND PATENT MEDICINE

What a man eats and drinks is so important to the welfare of his body that the following facts about drinks which many people use every day cannot be omitted from a practical book on hygiene.

Chemists say that in these days he who uses an alcoholic beverage, whether as a drink or as a tonic, cannot know what he is really taking. He has paid for something which contains alcohol, to be sure, but startling revelations have been made about that which he may have received in its place.

In 1906 Dr. Warren, who was State Food Commissioner for Pennsylvania at the time, made an official statement in which he said:

> Out of 600 samples of alcoholic liquors 450 samples were found to be adulterated. Wood alcohol, causing nerve atrophy, convulsions, impaired vision, blindness, and even death; salicylic acid, causing intestinal derangements, dyspepsia, and kidney diseases; coal-tar dyes that are active poisons and that cause diseases of the digestive tracts; sulphites that have the same effect; red pepper and other powerful irritants,— are some of the adulterations which lurk in many thousands of bottles and kegs of whisky, wine, beer, and other intoxicants that undoubtedly will be placed on sale within the next year. The flood of this poisonous

stuff has just commenced. A new legislature will not meet until January, 1907. It is necessary, in the meantime, that public attention be called to the dangers that lie in the use of adulterated drinks.

On the 15th of April, 1907, the general manager of the St. Louis Wholesale Liquor Association wrote a letter to the liquor trade in which he said:

> We retail dealers have allowed the "reduction rogues" to swindle us out of millions by substituting for good whisky, which we paid them for, a compound that would kill a horse if he drank it. We have unwittingly sold this accursed poison to the youth and the flower of our manhood, many of whom have been crazed, have lost their manhood, their honor, and their all, because they drank it. Their mothers, their sisters, their fathers, their brothers, and their friends are driving us retailers out of business.

Perhaps we wonder why alcoholic drinks should ever be adulterated. One simple fact helps explain the situation.

All the wine-producing districts of America and Europe combined do not supply enough of the different kinds of wines to meet the demands of those who wish to use them. But water is cheap; it is therefore added for bulk, and such drugs are put in as will give the desired taste and at the same time make a man feel as alcohol itself makes him feel after he drinks it. Sadly enough for the one who drinks, few things but poison can accomplish this last result.

Those who understand the danger which lurks in alcohol may be inclined to ask if, after all, the water and the

drugs do not make a safer mixture for a man than the drink which holds more alcohol. The answer is that such poisons as are used in adulterating alcoholic drinks are often even more violent and more harmful to the body than alcohol itself.

Some time ago the legislature of Ohio asked Dr. Hiram Cox, a distinguished chemist, to make a thorough examination of alcoholic liquors. He worked on the subject for two years and in a letter afterwards said:

I have made over six hundred inspections of stores and lots of liquors of every variety, and now positively assert that over ninety per cent of all that I have analyzed were adulterated with the most pernicious and poisonous ingredients.

Another letter says:

I called at a grocery one day where liquor was being sold. A couple of men came in while I was there, and called for some whisky. The first one drank, and the moment he drank the tears flowed freely, while at the same time he caught his breath like one suffocating or strangling. The second man drank and went through like contortions. After they had left I asked the proprietor to pour me out a little in my tumbler. I went to my office, got my apparatus, and examined it. I found it seventeen per cent alcoholic spirits when it should have been fifty, and the difference in percentage was made up by sulphuric acid, red pepper, pellitory, brucine, and strychnine.

In commenting about it he says, "One pint of such liquor at one time will kill the strongest man."

Judging by its name our port wine comes from Oporto, Portugal. But Mr. Cyrus Redding once made a report

on the subject to a committee appointed by the House of Commons, England. He said that every year Oporto exports 20,000 pipes[1] of wine, but that England alone uses 60,000 pipes of this same wine each year. Where, then, does the vast quantity of port wine come from that is used in the rest of Europe and in America?

Mr. Redding shows that this is the manufactured result of what has passed from hand to hand through the wholesale and the retail dealers. Water, poisons, coloring matter; more water, more poison, and more color, — these mark the steps of its progress, until the combination of water and chemicals is finally sold as fine port wine imported from Portugal.

From first to last the work of concealment is so well done that even an expert cannot tell by taste, smell, or color that it is a dangerous compound of chemicals. A chemist, however, with his apparatus, can always find the poisons.

These facts, which no one thinks of denying, do not mean that those who use alcohol are in danger of being killed suddenly by it. We ourselves know that this is not true. Multitudes of people drink more or less frequently throughout their lives, and almost never does even a newspaper reporter hear of a man who has dropped dead because he drank. If he should hear of such a case he would certainly report it at once.

[1] One pipe is equal to 126 gallons.

No, the newspaper reporter is not the one to go to when we wish to know about the life-and-death results of drinking. To get such facts we study the statistical tables of life insurance societies. There we find that he who uses alcohol reduces his chance for life by weakening the power of his body to resist disease microbes.[1]

A chemist is able to show how alcohol is formed even in some most carefully prepared homemade drinks. A friend of ours once said: "I never use alcohol in any shape. For the sake of making sure about it I even put up my own wine from grapes that grow on our farm, and we have cider which we make ourselves, from our own apples, ground up in our own cider mill." Then with a happy smile she added, "So you see no one has the ghost of a chance to put a drop of alcohol into anything we use."

As this friend talked a chemist who listened grew more and more astonished. By every word she spoke he saw that she knew absolutely nothing about the way in which alcohol is formed from fruit juice and from grains. Naturally, therefore, when she asked for his opinion about homemade drinks it was her turn to grow astonished, for he gave her a few chemical facts which showed that in her innocent ignorance she herself was making alcoholic drinks and giving them to her equally innocent and ignorant family. I give a few of the facts. Every chemist will vouch for them.

[1] A good deal is said about this in *Town and City*, Chapter XI.

1. If fruit juice is boiled, bottled securely while hot, and kept in a cool place, no alcohol will be formed in it. Even after several years the juice will be as sweet and as free from alcohol as when it was put up. Unfermented wine is made and kept in this way.

2. Fruit juice that is unboiled and left exposed to the air ferments; and this fermenting is a process that produces alcohol. Even if the juice has been boiled, if it is left so that air can get to it, alcohol will be produced in it before long.

3. Any fruit juice that begins to ferment before it is bottled will have alcohol in it when it is opened for use. The same is true of all kinds of beer.

The explanation of these three facts is as follows: Sugar — that is, sweetness — is found in all ripe fruit and in much that is unripe. When this sugar is kept wet and warm and exposed to the air and to ferment microbes, called yeast cells, which are in the air, it is gradually changed by the microbes into two things, carbon dioxid and alcohol. These two substances are present, then, in all wine, cider, beer, and similar drinks, whether they are made at home or elsewhere. In fact, the place where drinks are made makes no difference whatever in the amount of alcohol that is formed in them. Sugar in the liquid and microbes of ferment in the air explain the whole process. Beer is made from grain which is kept in a warm, moist place until it is well sprouted. This is necessary

because the process of sprouting turns the starch of the grain into sugar. From this point onward the fermenting is the same for drinks made from fruit juice and from grain. Root beer is made by putting sugar into a liquid made chiefly from roots. This ferments and we have root beer with its alcohol.

A bottle of champagne pops when you open it. Why? Because ever since the cork was put in ferment microbes have been changing the sugar of the liquid into carbon dioxid gas and alcohol. And now when the cork is loosened the gas within drives it out with a bang. Carbon dioxid is harmless in a drink, but alcohol is just as harmful in homemade wine and beer as in any that is bought. Beware, therefore, of the danger when you meet it. If fruit juice has not been boiled and bottled promptly, or even if it has been boiled, if it is allowed to stand open so that air can get to it, it will contain the alcohol which you wish to shun.

Aside from alcoholic drinks, however, chemists find that many patent medicines also contain opium, cocaine, alcohol, and other strong poisons. And just because these poisons are so powerful the innocent victim may find comfort for a season. His nerves may be quieted, his pain relieved, but later comes the curse. That which seemed so helpful often ends by hastening the progress of the disease it was supposed to cure. This is especially true of consumption. Or, instead, the drug habit may be formed

through medicine, and a man may discover too late that he is doomed.

Chemists testify that most medicines which go by the name of "tonics," "bitters," and relievers of pain of different kinds contain a large per cent of alcohol. Often as much as one quarter of the entire liquid in the bottle is alcohol.

In view of their disclosures these men and others have insisted that innocent people should not be cheated into the use of any poison through ignorance of what they are buying. These scientists have indeed been so much in earnest and so active in their agitation of the subject that at last the United States government has passed a law which helps the case greatly. It demands that the names of every poison in a bottle of patent medicine shall be printed plainly on a label and pasted on the bottle. The amount of alcohol must also be stated on the same label.

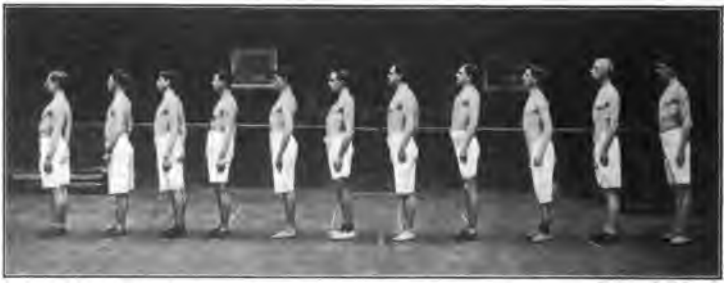
If a bottle of patent medicine bears no such label it is evident that its contents hide neither alcohol nor poison; it has no confession to make. If there is a label, remember that as a rule each name on it stands for a poison.

He who is unwise enough to buy patent medicine should balance his mistake by being wise enough to study the label before he uses the contents of the bottle.

CHAPTER XX

EXPERIMENTS IN EATING

It was a novel thing in the history of the world for men who were connected with a national army to serve their country by being used as a sort of laboratory for food experiments. But this was done by certain soldiers of the United States army in the year 1903.



SOLDIERS WHO SERVED ON THE EATING EXPERIMENTS

Professor Chittenden of Yale University had decided to conduct some scientific experiments on a rather large scale. He began with himself, enlisted the help of others, and finally had in hand thirteen soldiers whose ages ranged from twenty-two years and six months to forty-three years.

Close attention was given to the men in several ways. At quarter of seven each morning they were weighed.

This was necessary, for they were eating about half as much meat as usual, with somewhat less of other kinds of food, and it was important to know each day whether they were gaining or losing by the new course of diet.

At seven came breakfast. Here each separate kind of food was weighed before it was given to the man who was to eat it. What he did not eat was also weighed, that Dr. Chittenden might know just how much had been used. Moreover, these men were allowed to eat only such food as was served to them. In other words, for each meal they were told when to eat, what to eat, and how much to eat. All eating between meals was strictly forbidden.

Aside from this close care about their food the men were not hampered in many ways. They went to the theater sometimes, worked in the Yale gymnasium an hour a day, had regular drill under their officers, and went to bed at ten o'clock.

No doubt the whole affair grew monotonous at times, and it has been said that a few of the men were inclined to protest against it. On the whole, however, they went through it without hesitation, and when they left New Haven at the end of six months Dr. Anderson, director of the gymnasium, wrote about them as follows:

The men were not above the average standard physically when they began their work, this standard being set by applicants for positions as firemen and policemen, not by college students. At the end of the

training they were much above the same standard, while the strength tests were far greater than the averages made by college men.

These tests did not settle all food questions, but they seemed to make it clear that even soldiers may gain strength on much less meat than they have been in the

Ten of the Soldiers taking Exercise in the Gymnasium

habit of eating. As for the rest of us, science has proved that the work of the body is closely related to the food we give it, that the kind of food makes a difference in the quality of the work, that he who works little harms himself when he eats much, and that growing children need much more food than their inactive elders.

All scientists agree that food does two things for the body:

1. Food builds tissue; that is, it makes the body grow by adding fresh tissue, and it keeps the body new by replacing all tissues as fast as they wear out.

2. Food produces energy by which the body does work and keeps itself warm. Food so used is the fuel for our engines.

We eat, then, for the purpose of meeting one or the other of these two great demands of the body, and our success or failure in life may easily turn on what we know or do not know about the value of our food.

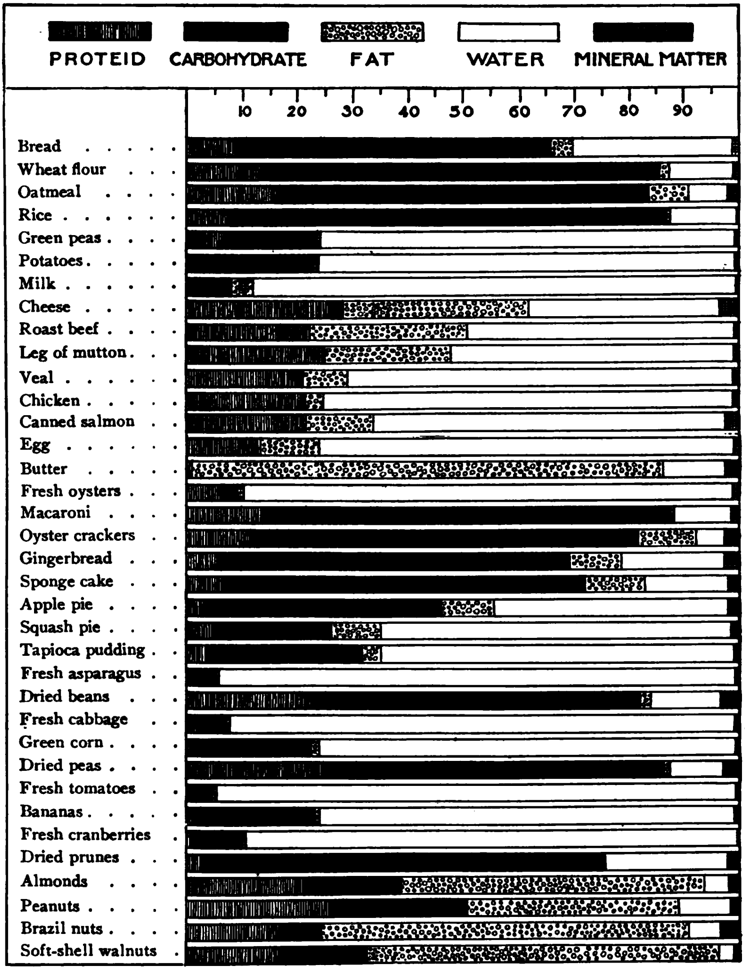
When Professor Chittenden planned meals for his soldiers his main thought was not as to whether he should give them beefsteak, mutton chops, fish, eggs, bread, or vegetables, but whether or not he was giving them the right proportions of certain substances which living bodies need if they are to do good work. This would be easier to understand if our bodies were blocked off in patches, with each separate substance firmly held in a special district of its own. In point of fact, however, the few general materials out of which our bodies are built are so closely intermixed with each other in blood and tissue that only the chemist can separate them. The next page shows his work in a table which is made up from the reports of the United States Department of Agriculture. It shows how the materials which the body

FOOD SUBSTANCES AS FOUND IN DIFFERENT ARTICLES OF DIET[1]

	PROTEID	CARBO-HYDRATE	FAT	WATER	MINERAL MATTER
Bread	8.9	56.7	4.1	29.2	1.1
Wheat flour	13.8	71.9	1.9	11.4	1
Oatmeal	16.1	67.5	7.2	7.3	1.9
Rice	8	79	0.3	12.3	0.4
Green peas	7.	16.9	0.5	74.6	1
Potatoes	2.5	20.9	0.1	75.5	1.0
Milk	3.3	5	4	87	0.7
Cheese	25.9	2.4	33.7	34.2	3.8
Roast beef	22.3	—	28.6	48.2	1.3
Leg of mutton	25	—	22.6	50.9	1.2
Veal	21.2	—	8.0	70.3	1
Chicken	21.5	—	2.5	74.8	1.1
Canned salmon	21.8	—	12.1	63.5	2.6
Egg	13.4	—	10.5	73.7	1.0
Butter	1.0	—	85	11	3
Fresh oysters (solid)	6	3.3	1.3	88.3	1.1
Macaroni	13.4	74.1	0.9	10.3	1.3
Oyster crackers	11.3	70.5	10.5	4.8	2.9
Gingerbread	5.8	63.5	9	18.8	2.9
Sponge cake	6.3	65.9	10.7	15.3	1.8
Apple pie	3.1	42.8	9.8	42.5	1.8
Squash pie	4.4	21.7	8.4	64.2	1.3
Tapioca pudding	3.3	28.2	3.2	64.5	0.8
Fresh asparagus	1.8	3.3	0.2	94	0.7
Dried beans	22.5	59.6	1.8	12.6	3.5
Fresh cabbage	1.6	5.6	0.3	91.5	1
Green corn	3.1	19.7	1.1	75.4	0.7
Dried peas	24.6	62	1	9.5	2.9
Fresh tomatoes	0.9	3.9	0.4	94.3	0.5
Bananas	1.3	22	0.6	75.3	0.8
Fresh cranberries	0.4	9.9	0.6	88.9	0.2
Dried prunes	2.1	73.3	—	22.3	2.3
Almonds	21.0	17.3	54.9	4.8	2.0
Peanuts	25.8	24.4	38.6	9.2	2.0
Brazil nuts	17.0	7.0	66.8	5.3	3.9
Soft-shell walnuts	16.6	16.1	63.4	2.5	1.4

[1] Notice that some of the substances in the table are moist while others are dry; and remember that before many of the dry foods are eaten a great deal of water is added to them. This is notably true of the cereals, of rice, and of flour. For example, what we buy as one pound of rice at the grocer's comes to the table as nearly four pounds of moist food. The chief difference between dry and moist foods is simply that when we eat dry foods we take less of the food and more water. Vegetables, fruit, meat, milk, eggs, puddings, and pies are moist foods. See the quantity of water in them which the table shows.

THE SAME FOOD SUBSTANCES SHOWN IN A DIFFERENT WAY[1]



1 These tables are made up from facts supplied by Bulletin 28 (revised edition) of the United States Department of Agriculture.

must have are distributed in some of the foods we eat. In this table the single word "carbohydrate" is used instead of the two words "sugar" and "starch."

Look over the long list, which is only for reference and not to be memorized, and notice that our entire supply of food comes from living and growing things; that is, from plants or from animals. Plants gather nourishment for themselves from earth and air and water. Animals cannot do this. Instead, by their nature they must live either on the flesh of other animals or on material which plants have gathered and stored up for their own use.

This fact gives an added interest to the table of foods. Notice that in every case the animal food is rich in proteid, and be ready to remember that proteid is the food substance which builds the tissues of the body. That is, when muscle is broken down through exercise proteid is used to build it up again.

Notice also that the plant foods in this table are rich in carbohydrates, and bear in mind the fact that carbohydrates are the food substances which produce energy, by which the body does its work and keeps itself warm. Proteid also helps in both these directions.

When more carbohydrate is eaten than is called for by the work of the body, the surplus is stored up as fat; and this fat is as important to the body for use in times of extra pressure as is money in the bank for a man who may at some time need more money than he has in hand.

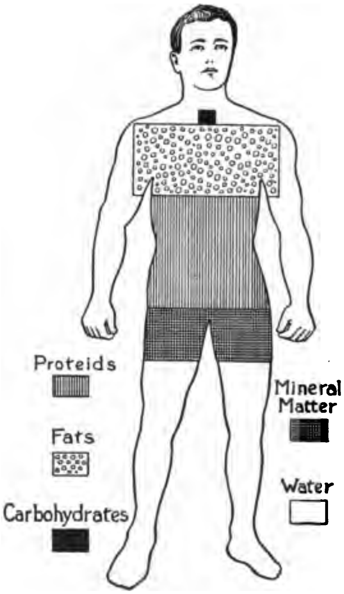
Too much fat is, however, a disadvantage, for an oversupply reduces the power of the muscles.

When more proteid is eaten than the body can use, the surplus is sent off through the kidneys. Those who eat too much meat often overtax their kidneys to such an extent that they suffer from rheumatism and gout. More is said about this in a later chapter.

A baby grows fast and takes little exercise; hence his food, milk, contains both proteid and carbohydrate. Later on the same child will be a man; he will then grow little and exercise much, and will therefore need several times as much carbohydrate (fuel food) as proteid (tissue food).

Study the table of foods carefully and decide which articles may be wisely put together for the same meal. Professor Chittenden himself had these food substances in mind when he planned meals for the soldiers. He knew that all kinds of meat and some kinds of vegetables are rich in proteids, that grains and vegetables are specially rich in sugar and starch (carbohydrates), that mineral matter which we need comes in table salt and is also found in most meats and vegetables. And he saw, as we do, that the great food questions turn upon the proteids and the carbohydrates. In giving directions therefore, he was careful to order a mixed diet of carbohydrates and proteids for the same meal. When, for example, he selected beans, cheese, or eggs, he gave little

if any meat; instead he provided foods rich in starch or sugar, with vegetables and fruit, for example, or with some simple sweet dessert.



THIS SHOWS WHAT PROPORTION OF THE HUMAN BODY IS COMPOSED OF EACH SUBSTANCE WHICH WE TAKE AS FOOD

Little carbohydrate appears because most of the sugar and starch which we eat is used up in the shape of heat and muscular work and sent from the body as carbon dioxid. When we eat more carbohydrate than we need, the surplus is stored up as fat. The diagram shows that the body keeps a good deal of this on hand ready for use

(Copied from *Practical Hygiene*, by Alice Ravenhill)

Housekeepers succeed best when they too keep sight of these proteid and carbohydrate facts. They are then able to make wise and nourishing combinations for their families. They know why a man receives as much nourishment from eggs and beans and cheese as from steak and roasts. They know why boiled potatoes alone are not so nourishing as creamed potatoes, and why pickles and tea and coffee are almost useless as food.

Just here it should be stated that food is needed not for nourishment alone but for bulk as well. Were it not for this we might be content to have our food condensed to small pellets and swallowed quickly with a mouthful of

water. The objection to this simple scheme is that the extended size and length of the stomach and the food tube have to be taken into account. They require food which shall be bulky enough to be acted on. Vegetables and fruit have special value for this reason. The same is true of graham bread and grains with the hulls on. Much of the tissue of vegetables and fruit is not useful as food, but it is of great value in giving bulk for the walls of the tube to exercise themselves upon.

There are those who feel very sure that they must eat meat of some sort every day. So indeed they must if they can provide themselves with proteid in no other way. But there are multitudes of equally active people who are intelligent enough to know that they can find all the proteid they need in other foods than meat.

CHAPTER XXI

CATS UNDER THE X-RAY

It is quite possible that the soldiers and athletes who shared in the eating experiments had no very definite notion about that which was to happen to the food which they swallowed, and it may easily be that some of them had not so much as heard about Dr. Cannon's experiments on cats.

These experiments were carried on in the laboratory of the Harvard Medical School, and the record of the work was published in 1898. Cats were chosen because they are easy to get hold of, ready to eat when they are fed, ready to sleep at almost any time, and easily controlled. Even among cats, however, Dr. Cannon had to choose carefully, for only those who were good-natured were useful to him.

Having made his choice he took bread, mixed into it a harmless chemical called bismuth,[1] fed it to his cats, and waited for results. The bismuth was put in for this one reason, that its presence in the food made it possible to get a shadow of the shape of the stomach by means of X-rays. From shadows he hoped to discover, very definitely,

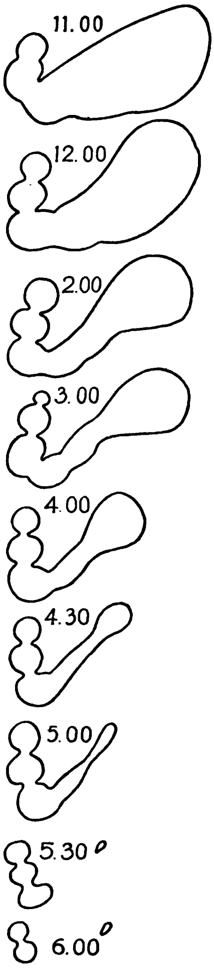
[1] The exact chemical name is bismuth subnitrate.

how the stomach moves during the time that it is digesting its contents. Dr. Cannon was fortunate in the cats he chose, fortunate in his helpers, and fortunate in what he was able to learn through the X-rays; for he learned facts which had never been proved before.

After being fed the cat was put in place for its shadow picture. The particular cat which I have in mind was fed at fifty-two minutes after ten in the morning. At eleven o'clock work was well under way in the stomach, and once every half hour after that, until twelve minutes after six in the afternoon, the kindly cat consented to be put in place to have its shadow studied. Dr. Cannon traced the shadows one by one, so that an exact record was kept of the size of the stomach from the time of the hearty feeding until there was nothing left to be digested.

During this time there had been an interesting course of events. When first seen the stomach looked like a small leg of ham with a curled-up tail to it. But when six o'clock came the leg shape had disappeared entirely, leaving nothing but the tail to show where the food had been. Moreover, at this time the cat seemed hungry and called for food, with which it was promptly rewarded.

The diminishing size of the stomach was perhaps one of the smallest lessons learned that day; for while the cat slept, and while the X-rays were focused on its stomach, another fact was noted. It appeared that food



CONTRACTION OF CAT'S STOMACH (MUCH REDUCED) DURING DIGESTION

which had newly arrived stayed quietly in the upper end of the stomach as if it were in a reservoir. Here the saliva which had been swallowed with the food had a longer time to do its share in the work of digestion. But as fast as supplies were needed farther on this reservoir contracted itself and sent its contents forward a little at a time.

It was also seen that the firm walls of the lower part of the stomach had begun to contract in a series of wave-like movements. These waves started near the middle of the stomach and moved towards the smaller end of the elastic bag. They followed each other in regular succession. Once every ten seconds a new wave took its start from about the same spot and traveled the same course down to the smaller end.

Indeed, whenever the shadows were studied during that day these waves were seen to be following each other with unceasing regularity. Moreover, as time passed and as digestion progressed this middle part of the stomach grew gradually more and more

slender, like a neck, while the larger end stayed large for a longer time.

Through his study of shadows Dr. Cannon learned that within about fifteen minutes after food is swallowed a slender jet of softened food goes with a spurt through an opening at the lower end of the stomach and out into the tube which is the beginning of the small intestine.

For all animals, including man, this exit for the contents of the stomach is guarded by a strong muscle called the pylorus, or keeper of the gate. And well does this keeper do its work. Sometimes with every wave that rolls in its direction it opens wide enough to allow a spurt of digested liquid food called chyme to go through. But sometimes it stays persistently shut while wave after wave pushes in vain in its direction.

For the sake of getting an explanation of this uneven action of the pylorus Dr. Cannon induced the cat to swallow a small, specially prepared tablet made up of starch paste and of bismuth, the chemical substance already referred to. He then watched the progress of this pellet in the stomach. He saw it stay for a long time in the large, bulb-like end; saw it gradually make its way farther and farther down as it was sent forward by the waves of contractions; and finally saw that for forty-two minutes after the pellet reached the pylorus that diligent gatekeeper allowed nothing to pass onward.

Over and over again the round bit of bismuth and the mass of soft food in which it floated came up to the pylorus as if to demand free passage through. And over and over again, just as often, the soft as well as the hard was positively rejected and sent shooting backwards, only to come again and again to be rejected.

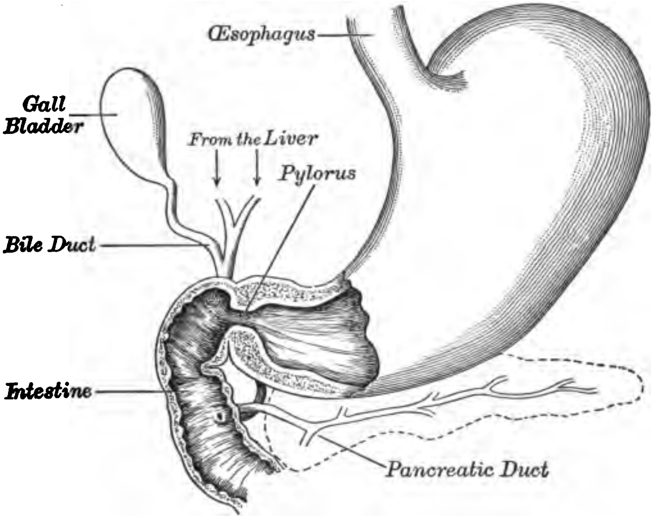
This was kept up until finally the most fluid of the food was refused no longer. It went onward. Later yet the pylorus seemed to give up all protest. It seemed to conclude that there was no hope of ever softening the bismuth. This also was then permitted to go on in company with food which was well prepared for advancement.

From this experiment it is evident that the disadvantage of any hard substance in the stomach is not simply that it is itself slow in passing on through the pylorus, but that it delays the progress of even such food as has already been reduced to chyme — food which should be receiving its next course of treatment in the food tube. The main objection to slow digestion is that after food has stayed too long in the stomach it grows sour and gives off gases which stretch the walls of the stomach and cause distress of various kinds.

The next time you eat in a hurry and are tempted to swallow unchewed lumps of food, think of all this and control yourself in time.

During the X-ray experiments there came an unexpected turn to affairs one day. Thus far Dr. Cannon had

been fortunate enough to have dealings with amiable cats only. They had eaten when he wished, had been quiet and well-mannered during the experiments, and had slept when required. In addition, their stomachs had gone



THE HUMAN STOMACH

Food reaches the stomach from the mouth through the œsophagus. While digestion goes on bile runs from the liver directly into the intestine; at other times the opening of the bile duct is shut, and instead of entering the intestine bile passes into the gall bladder, where it is stored until needed. The outline of the pancreas is shown by a dotted line

steadily to work when food was put into them, and had kept ploddingly at it until digestion was accomplished.

But a different type of cat came to Dr. Cannon's hands one morning. This one ate as promptly as the others, and when the X-ray was arranged the shadow showed at

first that the usual regular wave action of the muscular walls was taking place. Suddenly, however, the animal lost his temper. He seemed to feel outraged that anything should be going on which he did not understand. He refused to purr as did the other cats; he insisted on being released. Being in such a state of mind he was useless and had to go. But before he was dismissed it was seen that all the action of the waves had stopped. So much so, indeed, that the stomach was as inactive as if it were empty of food.

This led to close observation of the connection between the feelings of a cat and the behavior of its stomach during digestion. These observations in turn led to the startling discovery that whenever a cat is unhappy or disturbed in its mind by anger, anxiety, or distress of any description, the muscular action of the stomach comes to an end.

To prove this conclusively those who carried on the experiments were obliged to tease a well-disposed cat a little, even while it was under the rays. Before the teasing it purred gently and the wave contractions swept on with rhythmic regularity. But when the teasing began, and when the cat began to feel mental distress and to show it, every wave ceased; the stomach stopped its work abruptly and absolutely. If, then, Dr. Cannon stroked the cat it was at once happy; it purred, and with that purring began again the squeezing and the

monotonous, regular progress of the waves along the walls of the stomach.

Doctors have always known that an unhappy man does not digest his food so well as the same man when he is happy; but none have known just why this is so. It is evident, however, that there is some close connection between happiness and the power of the stomach to keep up the squeezing movement of its waves.

In view of this discovery, nothing could be clearer than the fact that if we wish good work from our own stomachs we must be neither worried, nor anxious, nor angry, either during the time that we are eating or so long afterwards as food is in our stomachs waiting to be digested. For the simple sake of health, therefore, the calm and happy mind is greatly to be desired.

CHAPTER XXII

PURE WATER AND CLEAN MILK

Year after year, for thirty-five years, people died in Pittsburg, Pennsylvania, under the scourge of typhoid fever. As the city grew, the number of deaths multiplied until, during 1907, 622 people died of typhoid alone.

But the misfortune was even worse than this; for besides those who died were the thousands of other people who suffered but did not die. Hundreds at a time, during each month of each year, were ill in their homes and in the hospitals of the city. They lost money because they could not work for daily wages. They paid out for doctors' bills and medicine savings that were intended for food, fuel, clothing, and house rent. Thousands of children were hungry and cold because their parents were too ill to care for them and too weak to work. It is indeed estimated that for each person who dies of typhoid fever eight other persons are ill with it.

So matters progressed from bad to worse for thirty-five years. In the meantime a generation of people came and went. And what was the explanation of this death rate? Just one thing. The drinking-water of

Pittsburg. Why then did the citizens use it? Because at that time multitudes of people did not know the facts about pure and impure drinking-water. They did not know that every case of typhoid fever is started by a small living thing which comes from the body of some one who has the fever. They did not know that this microbe is harmless unless it gets into our mouths and we swallow it alive. They did not know that their own drinking-water was loaded with living, active typhoid microbes which had come direct from the bodies of other people. They did not even know that boiling kills disease microbes, that a dead microbe injures no one, and that any water that has been boiled, no matter how wretched it looks, is safe to drink because it is free from living typhoid microbes.

And just because they were ignorant, multitudes of honest, hard-working people in Pittsburg took city water as it came from the faucet and drank it without fear.

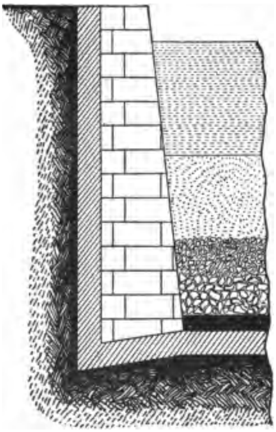
Perhaps we wonder why this particular water was so full of the microbes. Any map of that section of the country gives the explanation. Notice the location of Pittsburg. See how it lies at the point where the Allegheny and Monongahela rivers join to form the Ohio. Follow the two streams upward and notice that all the way along towns and cities are ranged on both banks of both streams. There are over seventy-five of these groups of houses, and their united population gives

a total of over 350,000 human beings. This then throws light on the entire water problem of Pittsburg, for it turns out that each of these towns and cities pours all its waste water, its sewage, into the river on whose banks it stands. A most natural riddance of it surely, for the river carries the waste off down the stream. But think of the next step in this water history.

TOWNS THAT CONTAMINATE DRINKING-WATER

Not only does each town empty all its sewage into the river, but each town also takes all its drinking-water from the same river. In other words, the sewage of each town becomes part of the drinking-water of all the towns that lie farther downstream. Naturally the mixture grows constantly worse, and by the time it reaches Pittsburg it is fearful stuff to drink. Nevertheless, just as it was, without any pretense at killing the microbes or taking them out, this liquid compound of water, waste, and filth was in those days turned directly into the huge water pipes of Pittsburg, and the masses of the people drank it with no suspicion of danger. Had they known the peril and the way of escape they would have saved themselves.

We ourselves know that if there are no microbes in our drinking-water, however wretched its color and taste may be, it cannot by any possibility give us typhoid fever. In the case of Pittsburg, however, many persons upstream had that very fever, and sewage with its load of microbes from those who were ill was being sent from city to city as the water rolled onward. Pittsburg suffered most, simply because it was farthest downstream.



SAND FILTER
From coarse gravel to fine sand

Then came an abrupt, astonishing change in the death record. During the single month of October, 1907, 596 persons had been ill with the fever. But during the month of October, 1908, there were but 96 cases of it in the city; and deaths for the entire year dropped off in like proportion. This changed record has continued to the present day. And the explanation of the entire change rests with the sand filters which were set to work in 1908. These filters are near the city, 46 in number, and easy to find. Each covers an acre of ground; each is about five feet deep; each is a separate bed of pebbles, gravel, and fine sand, — pebbles on the bottom, sand on top. River water is turned on these filters. It soaks through slowly and

is carried in water pipes to the homes of Pittsburg. Nothing could be more unpretentious and matter of fact than these huge sand filters. But they are nothing less than the life preservers of the city. They purify river water, make it fit to drink, and by so doing save hundreds of lives each year.[1]

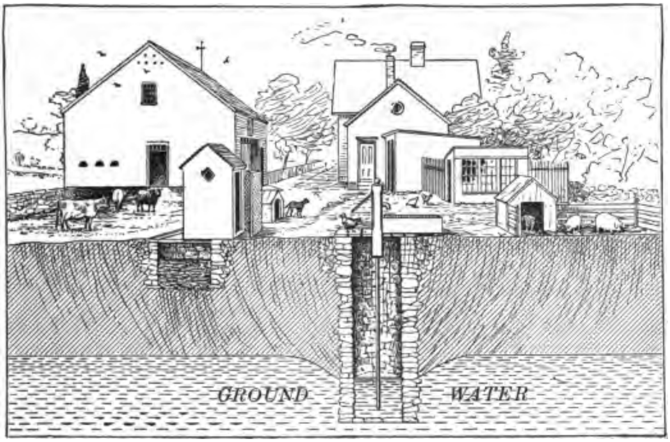
Now turn these facts to your own account. Think for a moment of the water conditions in your town. Where does your drinking-water come from? If from a river, study some map and try to decide whether or not other people farther upstream are sending their sewage down to you. If so, when typhoid fever attacks any person in that town you yourself will be in danger. Clearly enough, then, all river water that is exposed to human contamination should be either boiled or sent through out-door sand filters before it is used as a drink. A small filter in the house does not purify water in the same way. It takes out dust and color, but it does not remove disease microbes.

Perhaps your drinking-water comes from a lake. If no human beings send sewage of any sort into that lake, water from it may be used fearlessly as a drink. Generally, however, large lakes receive much sewage from houses and towns that stand on their shores. For safety's sake, then, such lake water should be either boiled or filtered.

Perhaps you draw water from a cool country well and feel very safe as you drink it. Still there may be danger

[1] The book *Town and City* explains the mystery of the sand filter.

even here. Last summer two friends enjoyed what they considered delicious water from a well in the country. One month later both men were down with typhoid fever and one of them died. What was the trouble? Those who examined the surroundings afterwards saw that the



DRINKING-WATER FROM A WELL

Notice that both well and cesspool are near the house. The contents of the cesspool soak through the ground without hindrance and contaminate the water which supplies the well. If typhoid microbes are in the cesspool they will get into the drinking water. — From *The Human Mechanism*, by Hough and Sedgwick

well was too near the dwelling house to make it safe. Water from the surface of the ground found its way into the well, and with it had gone sewage from a man who had had typhoid fever in the house. The water itself was cool and clear as crystal. Neither by its taste, its color, nor its odor did it tell any tales about itself. Dangerous microbes

were, however, concealed in it. This peril from well-water is so real that many a village which depends on wells is more in danger from typhoid fever than are large cities which supply themselves with water brought to town through pipes from some pure though distant source.

Judging by the facts, then, it begins to look as if water were encompassed by danger. So it is wherever sewage from man can in any wise reach it. For this reason we have all grown more careful about the sources of our water supply. Some cities draw it from mountain springs and from small lakes which cannot be contaminated by man. Others build huge reservoirs and protect them. Here water is stored by the hundred million gallons at a time. Other places yet filter such water as they are obliged to use from undesirable sources. For example, London, in England, must use water from the Thames. Yet as this river passes by it carries sewage from many towns on its way to sea. Nevertheless even the terrible water of the Thames is so purified by sand filters that London is remarkably free from typhoid fever.

It is raining at the present moment, and I think of the pure water that comes from the skies. Not a microbe is in it, for microbes never ascend to the clouds when water evaporates. Floating microbes may be in the air on a dusty day, but these are washed out by the first dash of raindrops. Everywhere in the world, therefore, rain water, direct from the sky, is safe to drink. And when

this water is caught in tanks and kept away from all human contamination it continues to be the safest water we have.

In deciding to live in this town or that always make some inquiry about the water supply of the different places before you come to any decision as to where to make your home. For life itself depends on the purity of our drinking-water.

Then, too, there is that other important drink, the milk we use so constantly. Even here there may be danger from harmful microbes.

In Springfield, Massachusetts, in 1882, typhoid fever suddenly appeared in several different homes at about the same time. On investigation it was found that all who had the fever took milk from the same milkman, and a little later it also appeared that a man had just had typhoid fever in the home of the farmer who sent the milk to town. Just how the microbes reached the milk no one could say. Perhaps the milk cans had been washed in water that contained the microbes. Perhaps the microbes were on the hands of the man who did the milking. Perhaps some one had put contaminated water into the cans to increase the milk supply. However it was done there was no doubt about the fact. In one way or another typhoid microbes had reached the milk and passed the disease on. Scarlet fever has sometimes been carried in the same way.

In the town where I live there is just now quite a rivalry over the milk business. Two men are trying to outdo each other in the perfection of the milk they deliver. On one neat-looking milk wagon the printed sign reads, "Clean Milk Dairy"; on the other there are but two words, "Pure Milk." As for ourselves who buy the milk, we know that from both wagons the best of milk is delivered to us. We are sure of this because both dairies believe in cleanliness. They know that the cleaner the milk the fewer the microbes, the fresher the milk the fewer the microbes, the colder the milk the fewer the microbes.

In both dairies, therefore, clean cows are kept in clean stables; they are milked by clean men who wash their hands before they do the milking. Clean pails, clean pans and bottles, all are kept fresh and sweet through the use of boiling water and "live steam." Those who conduct this business know that microbes multiply faster in warm, unclean milk than elsewhere, and that each speck of mud, each bit of horsehair, that enters the milk carries countless microbes with it. They also know that each of these microbes begins to multiply at once and that no amount of straining can take out microbes after they are once in a liquid. These men are therefore wise enough to be careful of the milk supply from the time it is drawn until it is delivered. In addition they keep it cool from start to finish.

It is quite otherwise, however, with certain men who carry on the same important business in a neighboring town. They do not seem to know that dirt and microbes go together, that the more dirt the more microbes, that the older the milk the more microbes, that the warmer the milk (before it is cooked) the more microbes. As a result their milk is not such as we should wish to use.

If at any time you are not sure about the history of your milk supply, and if you wish to make it perfectly safe, remember the old lesson that boiling kills microbes wherever they are. Two things may render milk harmful:

1. The presence of disease microbes which may reach it through carelessness.
2. The presence of too great a number of microbes which are harmless in themselves.

For young babies this last danger is the real one. Various cities are beginning to take this fact into account and are trying to supply the babies of the city with milk which carries as few microbes as possible and no danger whatever. By means of pure milk the city of Rochester, New York, reduced the death rate of its babies from one thousand in 1892 to less than five hundred in 1904.[1] Thus one example is added to another and, the world over, fathers and mothers are learning that the kind of milk they buy helps decide what the death rate of their youngest children shall be.

[1] *Town and City* tells how Rochester purified the milk and saved the babies.

CHAPTER XXIII

FROM FOOD TO BLOOD, OR PERISTALTIC ACTION AND THE VILLI

In the same laboratory of the Harvard Medical School and probably on the identical cats already described a second set of experiments was made to determine what the history of chyme is after it has gone through the pylorus into the tube which receives it.

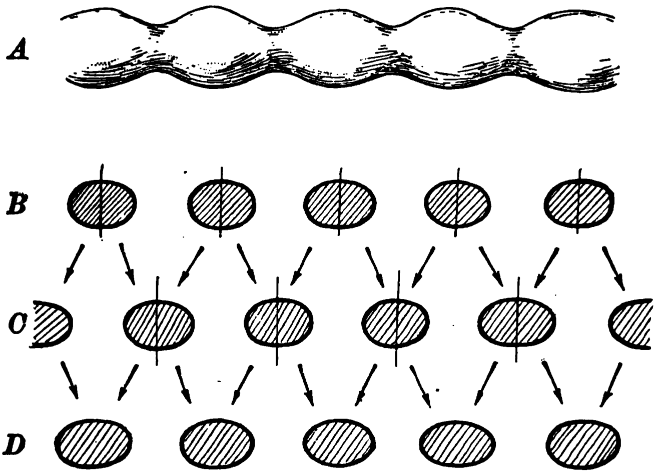
This tube, which in man is about twenty feet long and about three inches around, is folded back and forth in compact compass just below the stomach. It is called the small intestine, and within it go on some of the most marvelous of our involuntary muscular contractions.

The entire scientific world was in doubt as to precisely what happens in the tube until, through the X-ray, through the cats, and through Dr. Cannon's continued experiments, the mystery was explained by the discovery of a series of surprising facts which could be readily understood.

Previously scientists had known that chyme, as it leaves the stomach, is as liquid as pea soup; that certain juices are promptly poured upon it from the liver, the pancreas, and the lining of the tube; and that in its most liquid

state the food passes through the sides of the small intestine and is sent into the blood supply of the body.

All this has been acknowledged for many years. It has also been stated distinctly very often that food which



THE FOOD TUBE AND ITS CONTENTS

A, the tube as it contracts at regular intervals; *B*, the contents of the tube after the first contraction; *C*, after the second contraction; *D*, after the third contraction. The line through the middle of the oval piece shows where each was divided by the tube as it tightened just there. The arrows show how the new halves were alternately forced apart and driven together by the repeated contractions of the tube itself

leaves the stomach as chyme is to be called chyle while it makes its journey through the long tube. It is well to remember these new words and these statements, for they make the continued history of digestion easier to understand.

After the stomach had done its work through waves of motion; after gastric juice had softened and dissolved the food by degrees; after the pylorus had allowed such chyme as was soft enough to pass through its narrow portal; after bile from the liver and pancreatic juice from the pancreas had turned this chyme to chyle, then followed what proved to be a most surprising discovery.

At first the X-rays showed the shadow of the chyle as it lay along in the various loops of the folded tube. All was inactive and quiet for a season. The chyle was motionless and gave no sign of progress. Then came slight warnings, — a quiver at first, a mere agitation. Then without further delay activity began in earnest. The stretched-out length of chyle within an entire loop was suddenly divided into separate bits of equal size. The tube indeed, without apparent cause, had tightened itself at regular intervals; like a flash it had divided its contents into a series of oval masses of equal size. After this it halted for a moment. But within two seconds there was another contraction, and each bit was now divided through the middle; their halves were compelled to unite with neighbor halves on either side, and a series of new whole ones appeared.

Thus, back and forth with every two seconds of time, the rapid peristaltic action was continued.

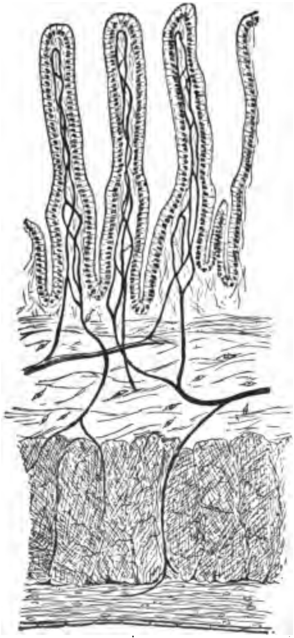
While it lasted the small particles were alternately so quickly divided and so quickly forced together again that

Dr. Cannon speaks of them as rushing together "with the rapidity of flying shuttles, the little particles flitting towards each other and the larger segments shifting to and fro, commonly for more than half an hour without cessation."

In the meantime the food within the tube was advanced but slowly on its way. It seemed to stay in place for no other purpose than to be acted on by the squeezing and the relaxing of the tube. Whether the chyle was thin or thick, whether the activity of the tube was slower or more swift, the squeezing was kept up so unweariedly that each particle of chyle was affected by it. All that lay within the folds and turns of the small intestine was brought into contact with the sides of the tube tens of thousands of times while it was gradually being absorbed. That which could not be used went on into the large intestine, whence it would finally leave the body.

To an ignorant person this endless activity might seem to be a waste of energy and a needless hindrance to the chyle as it works its way along. In point of fact, however, rapid movement of chyle through the food tube would be a distinct disadvantage; for from the time food is swallowed until its journey is ended the one necessity is that it should be thoroughly prepared to be used by the regiments of threadlike villi which line the small intestine. Chyle, indeed, is improved by every juice and every squeeze which it receives before it is absorbed by the villi.

So true is this that food which does not get the treatment it needs will be rejected by each villus which it meets as it travels downward, and will end by forming part of the final waste of the body. When this occurs to food which we have taken the pains to cook and chew and swallow, not only does the body lose the strength it should gain, but the tube itself is in danger of becoming clogged. And here it is that we face again the problem of body waste.



VILLI THAT FORM THE VELVET LINING OF THE FOOD TUBE

A cut through the wall of the tube, showing some dark blood vessels and four villi

With all that we eat there is, of course, much that can never be turned into chyle and blood. As we know, however, this is useful as bulk. But nothing hinders digestion much more, or breaks down general health much faster, than the results which come from retaining waste in the body after it should be sent off. Waste decays in the body just as meat and vegetables decay in the pantry on a warm day. Both in the pantry and in the food tube decay comes from the action of microbes, and from both places decaying food should be cleared away promptly.

The habit of getting rid of waste at a definite hour each day, whether in the morning or in the afternoon, is of priceless value, for that which the villi reject is worse than useless to the body.

It would seem, then, that from first to last each mouthful of food which we swallow is being put into shape for the villi, and that they use it or not without the slightest reference to our wishes in the matter. This indeed is true, and the number of these independent workers is counted by the hundred thousand and the million. Each separate one is a tiny finger-shaped structure, ready to absorb such chyle as shall meet its demand; each stands beside its neighbor, helping to make the soft, velvety lining of the twenty feet of tubing; each does its independent work, yet all are united in drawing nourishment from the chyle and in sending it on to the body through the blood.

Just here certain facts should be reviewed and condensed:

1. It is through the lining of the small intestine that all substances must pass (whether proteid or carbohydrate, fat, water, or salt) which are to enter the blood from the food we swallow.

2. The villi are, in point of fact, the lining itself drawn up into slender tubes for the sake of increasing the surface against which the chyle must be pressed.

3. Food passes through the villi much as lymph and plasma pass back and forth through the sides of the tubes that carry blood. This food must therefore be very liquid, for the villi cannot absorb any solid substance.

4. The great object of peristaltic action is to wash the chyle up against the villi, that they may be constantly bathed with fresh supplies of it.

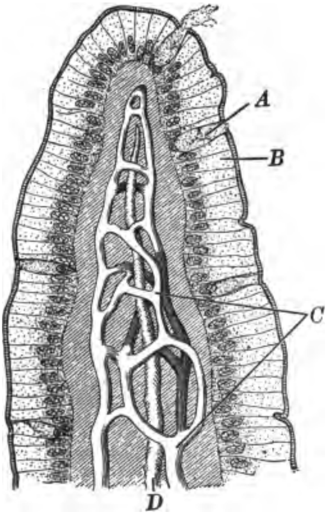
5. The mouth with its teeth and its saliva softens food and prepares it for swallowing; the stomach with its gastric juice softens it still further and prepares it for the pylorus; the food tube with its contributions from the liver and the pancreas gives to what we eat its final preparation for the villi.

When chyle which is squeezed against the villi is such as they can use, they absorb it and send it on through other tubes into the current of the blood. When, however, this chyle is not liquid enough, or not changed enough in other ways, they refuse it as absolutely as if it were a poison to them.

For each of us almost any well-cooked food can be turned into chyle which will pass through the villi; yet many a thin man and many a half-nourished woman shows by every sign of face and figure that the villi are not getting what they can accept.

In almost every such case the explanation lies in some mistake which the person is making. Perhaps he eats

so fast and chews so little that saliva does not have a chance to do its share of work. Perhaps he is so busy just before and just after eating that blood is drawn away from the stomach, leaving it less vigorous than it should be. Perhaps he worries so much, is so anxious and troubled about many things, that gastric juice fails to form and is thus kept from doing its part of the work. Or it may be that the unfortunate person has overeaten until his whole digestive system has rebelled. Whatever the cause, we know that we are nourished or starved according as we have been successful or not in preparing chyle for its last examination. If teeth and tongue, saliva, stomach, gastric juice, bile, and pancreatic juice have done their work well, the final test will be successfully met and passed; the villi will accept the food and we shall be nourished. If the test is not met, we shall suffer from lack of nourishment.



A VILLUS CUT DOWN THROUGH THE MIDDLE

A, a cell which manufactures mucus; *B*, the outside layer, which absorbs chyle; *C*, capillaries to supply each villus with blood; *D*, lymphatic

CHAPTER XXIV

GLAND LABORATORIES FOR THE AID OF APPETITE AND GENERAL HEALTH

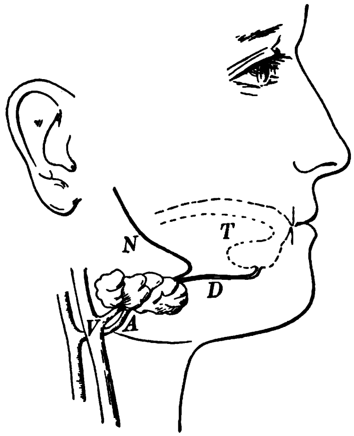
Although they did not understand what they were doing, dogs no less than cats have helped scientists who have tried to explain the laws of digestion for us. One such dog had a small tube fastened so ingeniously to his mouth that the saliva ran into it as fast as it was formed. Professor Pawlow watched and described the tests one after the other:

> I now offer such an animal a piece of flesh and, as you see, the tube fills up at once with saliva. I stop tempting the dog, hang on a new test tube, and give it a few pieces of flesh to eat; once more a strong secretion of saliva results. A new tube is now attached to the funnel, the dog's mouth is opened, and a pinch of fine sand is thrown in; again there is a flow of saliva. One may employ a number of substances in this way, when a similar effect is always produced.

Many different students have established the fact that the mouths of dogs and of men, too, are supplied with three sets of salivary glands, and that for dogs and men alike one or the other of the two following causes is enough to make saliva flow:

1. A great desire for some special kind of food.
2. The chewing of the food.

Prove these statements for yourself. Think of the most delicious thing you know anything about, and notice the effect on your mouth. Then again, when mealtime comes, or even now if you can get it, take a dry crust and see what you can do with it by the mere act of chewing. Use your jaws vigorously and before long you will find that you have turned that dry bread into something as easy to swallow as a mouthful of mush.



A SALIVARY GLAND

A, artery; *V*, vein; *N*, nerve; *T*, tongue; *D*, the tube through which saliva, manufactured by the gland, is emptied into the mouth

A wise man with weak digestion often chooses toast, crackers, and crusts rather than the most delicate custards. He makes this choice because he knows that dry food requires more chewing than food which is soft, and that for this reason it will receive the most from his salivary glands. He recognizes the value of three facts:

1. Saliva has the power to turn starch, a carbohydrate which cannot be used by the villi, into sugar, a carbohydrate which can be absorbed into the body. This is a different kind of sugar from that which we eat in food or in candy. Saliva also

helps change certain sugars which are hard to absorb into other sugar which is easy to absorb.

2. The more saliva we mix with the carbohydrate which we eat in bread, potatoes, and other foods the better prepared will that carbohydrate be for its next course of treatment.

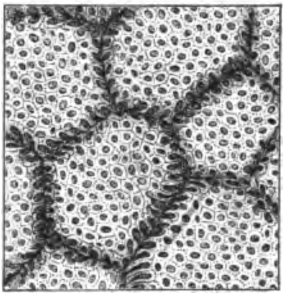
BRANCHES OF A GASTRIC GLAND HIGHLY MAGNIFIED

Gastric juice is here manufactured for the use of the stomach

3. Saliva which we swallow with our food will continue to act upon it during the time that it stays quietly in the large upper end of the stomach waiting to go on.

Carbohydrate, however, does not stand alone in its need of help from the mouth. A baby is allowed to draw no more than the finest stream of milk through the mouthpiece of his bottle. Those who feed the child seem to know that when milk reaches the stomach it is curdled at once, and that it is much better to have it curdle in small flakes, that can be more easily digested, than in one large lump which will be slow in digesting. Young babies who are allowed to drink milk rapidly from a tumbler are not likely to gain so much nourishment from this milk as they would if it reached the stomach a little at a

time. The same is so true for older people, too, that wise doctors strongly advise all human beings, whether young or old, to take their milk in sips and not in a pouring stream which will curdle in a mass as soon as it reaches the stomach. Milk is swallowed slowly, therefore, not because it needs the help of saliva but because it is more quickly digested when it has been curdled in flakes.



A FRAGMENT OF THE LINING OF THE STOMACH MAGNIFIED 20 DIAMETERS

Each spot shows the mouth of a gastric gland through which gastric juice flows into the stomach

After being swallowed food finds itself in the region of the stomach where there is rhythmic agitation from the waves of contraction. Here gastric juice acts upon it.

This colorless acid fluid can dissolve almost any proteid substance. A dog swallows an unchewed chunk of raw meat and the stomach digests it, not by tearing it to pieces but in a real way by dissolving it through the aid of gastric juice. Even the human stomach easily digests unchewed raw meat, but cooked meat needs more chewing and more help from the saliva. Moreover gastric juice is needed for both cooked and uncooked meats.

Numberless small gastric glands manufacture this liquid. They are packed snugly side by side within the

lining of the stomach. There each is supplied with its separate tube, ending in its own special outlet. The juice which these hosts of glands manufacture and empty into the stomach is of immense value in continuing the work of getting food ready for the villi and the blood.

As to what makes gastric juice flow fastest, and how the supply may be more or less controlled, Dr. Pawlow learned many things through his tests with the dogs.

> The stomach has been washed out half an hour ago, and since then not a drop of gastric juice has escaped. We begin to get ready a meal of flesh and sausage before the animal, as if we meant to feed it. We take the pieces of flesh from one place, chop them up, and lay them in another, passing them in front of the dog's nose, and so on. The animal, as you see, manifests the liveliest interest in our proceedings, stretches and distends itself, endeavors to get out of its cage and come to the food, chatters its teeth together, swallows saliva, and so on. Precisely five minutes after we begin to tease the animal in this way the first drops of gastric juice appear. The secretion grows stronger and stronger till it flows in a considerable stream. The meaning of this experiment is so clear as to require no explanation; the passionate longing for food, and this alone, has called forth under our eyes a most intense activity of the gastric glands.

In carrying on these experiments Professor Pawlow made it plain that dogs should not simply be tempted but should be really fed with that which has tempted them.

Several other facts were brought out by the same tests. Each was valuable from a scientific point of view, and I give them in close succession:

1. The more eagerly a dog desires food the more gastric juice will flow.

2. Gastric juice flows fastest and longest in connection with food that is enjoyed the most; for some dogs this is raw meat, for others cooked meat, etc. Dogs have preference as well as men.

3. The mere fact that something is in the dog's stomach does not make the juice flow.

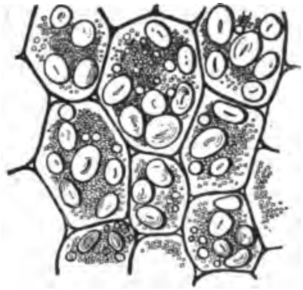
4. We all understand that the more the juice flows the better will the food digest.

From these important facts, learned from the study of digestion in dogs, men have learned why it is that a good appetite helps digestion. Indeed, those who make an application of the facts to their own lives come to the conclusion that hunger, if it is not too long continued, is one of the greatest blessings of life, and that he who eats only when he has earned an appetite for food is surest to gain the most nourishment from that which he puts into his stomach, because while it is there it will receive the richest supply of gastric juice.

But aside from digestion itself there is the great matter of preparing food for the glands even before we eat it. The fact that we cook our food is an enormous help in two important directions:

1. Cooking kills microbes. Recall the typhoid experiences of Pittsburg as they are given in Chapter XXII of this book, and remember that boiling would

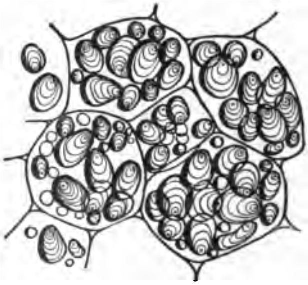
have killed the disease microbes and made the water safe to drink. The same treatment will kill other disease microbes whether they are in milk or meat or food of any kind.



FROM THE SEED OF THE BEAN
The larger granules are starch, the smaller ones are proteid

2. Cooking breaks starch cells open and makes it possible for saliva to get hold of the starch and help turn it to sugar.

We know already that unless this starch is turned to sugar every villus in the long tube will reject it, whereas if the change has been made it is quite sure of being accepted.



A BIT OF POTATO SHOWING STARCH GRANULES

In cooking oatmeal and other breakfast foods that hold a good deal of starch there is often danger that those who do not understand the main object of cooking will call food ready to eat when heat has not been applied to it long enough. An hour of boiling for oatmeal and half an hour for other more finely powdered grains is none too long for best results. Nothing is gained and much is lost by eating cereals that have not been cooked long enough.

This chapter teaches several important facts about eating.

1. We should so live and work as to have an appetite for our food.

2. We should chew food thoroughly and give prolonged stimulation to the salivary glands, thus fitting the food for the stomach and for the pylorus.

3. We should enjoy our food, thus stimulating both salivary and gastric glands.

4. Foods that contain starch should be well cooked and chewed.

Still another fact, shown in a previous chapter, is that for our best good we should be free from mental anxiety of every sort before we eat, while we eat, and after we eat.

CHAPTER XXV

GLAND LABORATORIES INFLUENCED BY ALCOHOL

In case you are thin enough to do it, you might slip your fingers up under the edge of the lowest ribs on your right side. There you will feel the smooth outline of the largest gland in your body. It weighs between three and four pounds, and it is to this place that the villi send much of that which they gather from the chyle. Indeed, it is only after this gathered liquid food has gone into the liver, and after a valuable substance called glycogen has been made out of it, that it is ready to be used by the tissues of the body. The liver, then, is a chemical laboratory where food gets its final preparation for the blood.

More than this, a large part of the impure or venous blood on its way back to the heart from the capillaries passes through the same great gland. There it is relieved of broken-down tissue and other waste which it has gathered from the body. From part of this waste the liver manufactures bile. Here, then, we have the circle of the occupations of the liver.

1. It changes liquid food which it receives from the villi into glycogen, which the body needs for nourishment.

2. It takes certain wastes from the blood, makes them over, and forwards them in the blood to the kidneys, to be separated there and sent from the body.

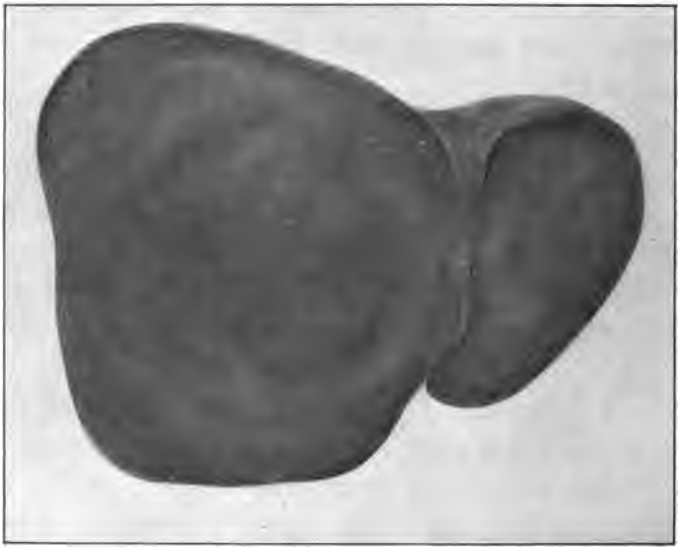
3. It manufactures bile as needed. This is sent to the small intestine, where it helps digestion and afterwards escapes with the other wastes of the food tube.

Clearly enough no man who knows these facts and who wishes to make sure of his health will care to ignore the welfare of his liver or to act as if he were ignorant of the laws which control it. Nevertheless many of the discoveries about these laws are so recent that even well-informed people have sometimes failed to hear about them.

This is true of my neighbor who complained about his liver the other day. He said the doctor advised him to eat less, to exercise more, and to give up his beer until he was in good shape again. But against this he protested. He said: "What I really need is strength, you know, and how can I get strong by eating less? As for beer, so far as I can see it is the one thing that really helps me. Can't I judge by my own feelings?" The doctor said he could n't, and the doctor was right. Follow the argument closely.

Those of us who have ever seen a piece of raw liver know how extraordinarily bloody it is. We also know that it is not bloody by accident on a particular day, but

that any piece of liver, on any day of the year, is deluged with its own blood. This is inevitable because the liver is always provided with an enormous number of small blood vessels, each one of which is in active service.



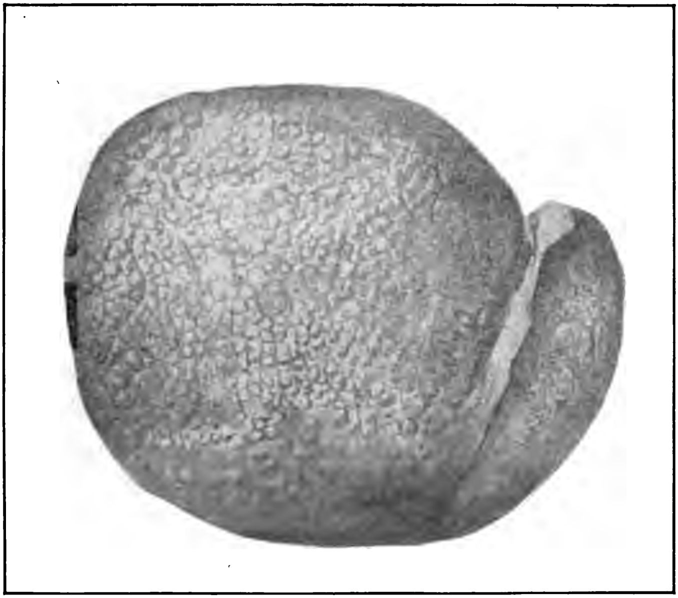
As the Liver looks when doing Good Work

(After Horsley)

When, therefore, the doctor gave my neighbor that advice about beer, he was acting in line with his knowledge of the effect of alcohol on blood vessels in general. He knew, what we also know, that wherever there is an unusual supply of capillaries and blood-carrying tubes of all sizes, there will alcohol do its paralyzing work. He knew that when blood vessels in the liver are somewhat

paralyzed and enlarged beyond their usual size, the liver itself is sure to suffer in a serious way.

When a doctor examines liver after liver as he finds them in the hospital and in the dissecting room, he



A DRUNKARD'S LIVER RUINED BY ALCOHOL

From its appearance it is sometimes called hobnailed

(After Horsley)

counts the ignorance of the unfortunate men no laughing matter. "A drunkard's liver again," he will say as he opens up the telltale gland. "No wonder the man died. It's a wonder he lived as long as he did with a liver of this sort to purify his blood supply for him."

That which the doctor finds is indeed a grievous sight, for a liver in the grip of alcohol is often swollen to double its natural size. It has been changed from a healthy, compact mass of energetic cells and tubes to an inactive mass of distended tubes and of cells heavily loaded with fat. In other cases the substance of the gland shrivels through the effect of alcohol.

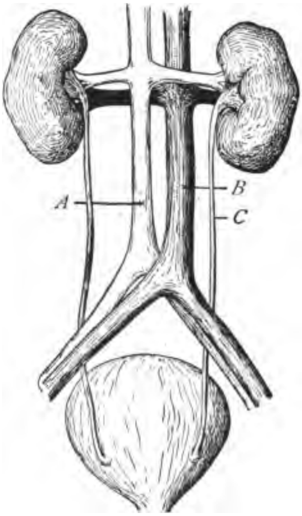
After a man's liver reaches the point where it can do no more work for him, the man dies and we pity him. But there are multitudes of other people who drink less and suffer quite as truly. By their ignorance of the laws of health and by their free choice they are setting a limit to the work which the liver may do for them. In all probability, by their regular use of alcohol they are slowly but steadily securing for themselves a gland which grows gradually more inactive and inefficient, a gland which by its inactivity is quietly preparing them more easily to fall a prey to diseases or to die earlier than they might have died. Life insurance societies know this so well that some of them charge the drinker more for his life insurance than they charge the non-drinker for the same amount of insurance.

Two other glands are also greatly affected by alcohol. These are the kidneys. They lie on each side of the lower part of the back, and their structure is a marvelous arrangement of closely packed microscopic tubes which are netted about by vast numbers of capillaries.

The special work of the kidneys is to rid the body of many kinds of waste. This brings us round to the subject of food again and calls our attention to two important facts about the disposal of waste which the blood gathers up:

1. If we have eaten more carbohydrate than we need, the surplus is stored up as fat and glycogen, while the waste takes the shape of water and of carbon dioxid gas which leaves the body through the lungs.

2. If we eat more meat than we need, the surplus is worked over in the liver and sent off as waste through the kidneys. Moreover, if the kidneys are overtaxed in their work, they fail to clear the blood entirely of its proteid waste. This waste may then settle in different parts of the body and result in gout, rheumatism, and kindred ills.

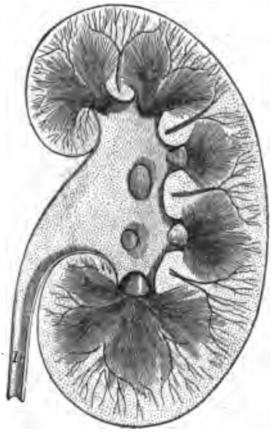


THE KIDNEYS AND THE BAG WHICH THEY SUPPLY WITH WASTE WATER

A, artery; *B*, vein; *C*, tube through which water leaves the kidney

Anything, therefore, that interferes with the prompt, healthy action of the kidneys is a misfortune to us. So true is this that many a man with kidney trouble has

been refused by insurance companies when he wished to get his life insured. Such business houses know that a person who has upset the power of his kidneys is a "poor risk." Because of this intelligent men listen intently when scientists tell them that alcohol has a direct effect on the kidneys and that the kidneys are specially affected by weak alcoholic drinks taken in large quantities. It is indeed a fact recognized by all doctors that those who use beer regularly, even though they drink it moderately, are repeatedly found to have trouble with their kidneys.



A CUT THROUGH THE KIDNEY

Notice the clusters of slender tubes; each separate one might be called a *laboratory*

Not only does alcohol make the capillaries of liver and kidneys inefficient, but it benumbs the working power of each gland. It robs them of their ability to be thoroughgoing, wide-awake chemists. For this reason it is as much of a calamity for these glands to receive alcohol as it would be for human chemists to be made stupid by the same alcohol during the time that they are carrying on important investigations in a modern laboratory.

CHAPTER XXVI

HAMPERED BY CLOTHING, OR ABOVE AND BELOW THE DIAPHRAGM

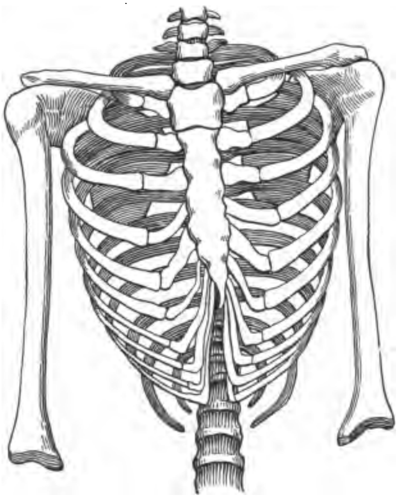
An unattractive woman is passing by at the present moment. Her shoulders are broad, her hips are large, her waist looks like a contracted isthmus which is doing its best to hold two wide-spreading peninsulas together. Both peninsulas are awkward in their movements because their proper relation to the waist has been lost. They rock from side to side, and the sight of the progress of the woman is not attractive.

But her outward appearance is the smallest part of the misfortune of her condition. She little suspects that others know more about her than she would dare acknowledge. Nevertheless the facts are clear to those of us who understand certain points about the structure of the human machine, and we acknowledge them.

We know that this woman has something hard and firm about the middle, soft part of her body, and that she has drawn this bandage up with such vigor that at this moment folds of crumpled flesh lie in creases just underneath the whalebones and the steel. We know that she is most uncomfortable from the pressure, but

that she endures it with a smiling face because she thinks she has made herself more slender and beautiful to look upon. Her ignorance goes even farther. It makes her willing to do more than simply rob herself of comfort.

Follow her condition down through those folded rolls of flesh and skin. Imagine that some new kind of X-ray is ready to reveal a few miserable secrets, and count them up for yourself:

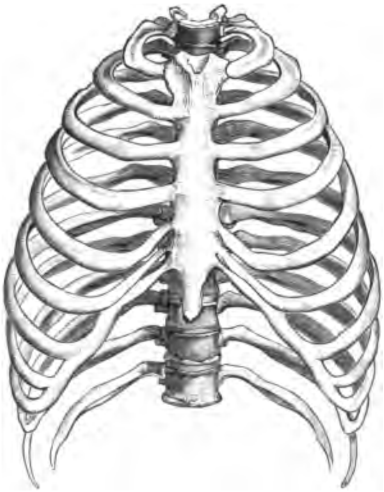


RIBS OF A YOUNG WOMAN WHO DIED AT THE AGE OF TWENTY-THREE

(After Tracy)

1. You will find yourself studying a liver which is crowded into such small compass that its capillaries and tiny tubes are folded and pressed upon each other until they labor under enormous disadvantage. This liver cannot do good work in preparing glycogen from the liquid food which it has received, nor thoroughly purify venous blood of its waste, nor manufacture other things from this waste. No wonder, then, that the waste kept in the system is gradually giving to this particular woman a dull complexion. Few things

more quickly rob a face of its bright pink and white than an inactive liver. By studying faces and waists you will have no trouble in coming to the conclusion that those who lace are apt to be the ones who paint and powder the most. Evidently they try to conceal the fact that the liver is not doing full work and that the complexion needs repairs.

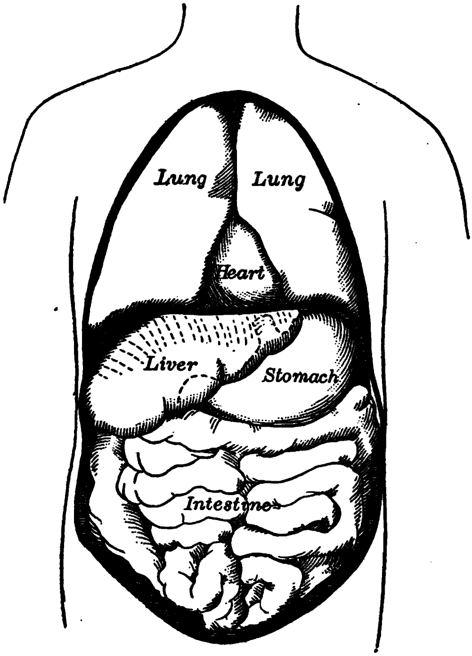

THE SHAPE THEY SHOULD HAVE HAD

2. Under the bandage the stomach endures the same pressure as the liver. It has less space in which to carry on its operations. It is consequently so hampered and hindered that indigestion often follows, and nothing is more fatal to a beautiful complexion than the results of this condition.

3. The upper long folds of the small intestine are pressed downwards; they, too, become inactive and food moves slowly through them. The disadvantage in this event is that the longer the food tarries on its way the more probability there is that it will decay and produce gas. Such gas is immensely

uncomfortable because it stretches the walls of stomach and tube alike and we feel the stretching.

Lacing does not always explain the size of the abdomen, for fat often settles there as persons grow older. But when a woman has persistently crowded her intestines downwards they finally stay out of place without the crowding. The walls of her abdomen are relaxed and flabby because they have not been able to get exercise. Everything which they inclose and which they should hold snugly and firmly in place is left sagging downwards. Each organ must therefore carry on its business as best it can under most unfavorable conditions.



INSIDE ORGANS THAT WERE SQUEEZED WHEN SHE LACED

This we find to be the state of affairs below the diaphragm. But what about the fate of the diaphragm itself? Recall for a moment what it is and what it does for us.

In a way it may be hard to think of ourselves as a double-story set of apartments, but such we are. For stretching across us from side to side, a little above the waist line, is a strong, broad, elastic partition of muscle called the diaphragm. Below it lie liver, stomach, intestines, and other important organs; above it are the heart and lungs with the large and small tubes which belong to them. Through the diaphragm go several good-sized tubes, a large artery, a large vein, and the tube which carries food from the mouth to the stomach.

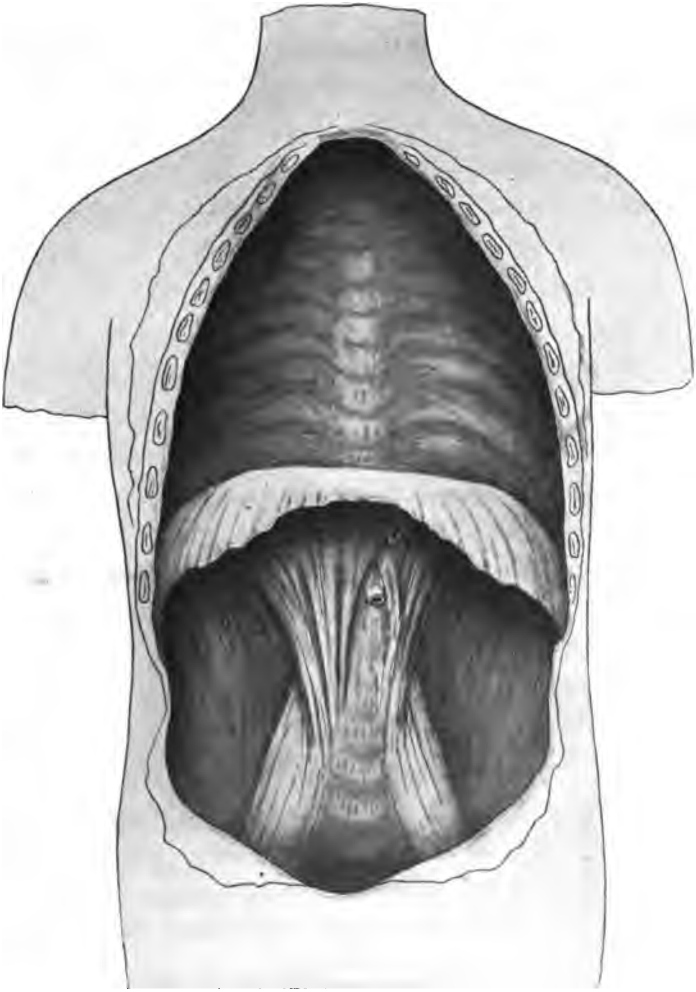
Above the diaphragm, then, we find the organs of respiration and circulation, while below it lie the organs of digestion and the great gland, the liver. Above the diaphragm blood is ridding itself of carbon dioxid; below the diaphragm blood is getting supplies of nourishment to carry to the tissues of the entire body.

But what active share does the diaphragm take in all this? Find out for yourself. Draw a deep breath. You may perhaps think that you are simply expanding your chest to the utmost. The truth is, however, that the drawing of your breath means that you are not only raising your ribs but also contracting your diaphragm from every side. A healthy person in hygienic clothing can prove it in this way: Lay your hand on your chest and take pains that the chest shall make absolutely no movement. You will find that you can breathe quite well by letting the abdomen expand and contract without the

least motion of the ribs. By doing so you have flattened down the dome shape which it usually has. When you can contract it no farther you know that your lungs cannot be forced to hold more air. This we call forced breathing. Through it you have forced your lungs to their full size.

But natural daily breathing is no less dependent on the diaphragm. This muscle is indeed the largest and the strongest breathing muscle we have. When it contracts air rushes into the lungs, and the upper story of the body grows larger, while all that lies in the lower story is exercised by the pressure of the diaphragm down upon it. When again the diaphragm relaxes, the pressure is lifted, air is squeezed out of the lungs, and the upper cavity is smaller again.

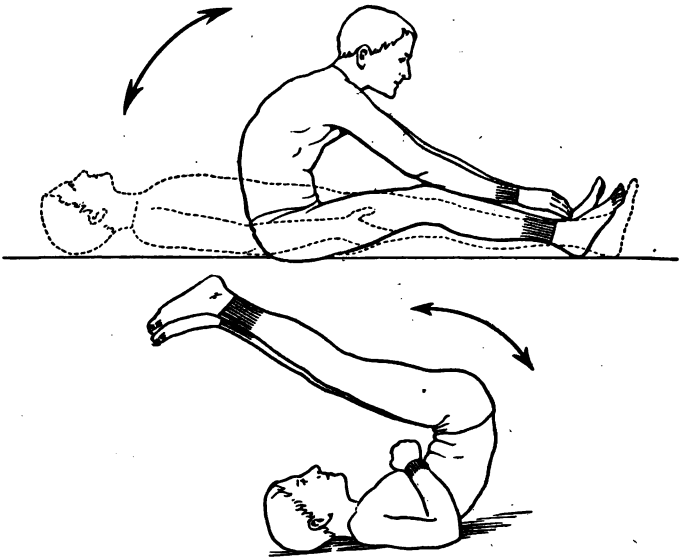
Liver and stomach also receive decided help from this rhythmic exercise, which continues throughout the days and the years of our lives. And the ignorant lady who laces implies that she is ignorant by her willingness to interfere with the healthful, regular action of her tireless diaphragm. By putting pressure on her lowest ribs and also on the organs contained both in her chest and in her abdomen she limits the work which her diaphragm can do not only for her lungs but also for her liver and stomach and small intestine. Moreover, she keeps these organs under such constant outside pressure that they have no chance for the relaxation which is also of importance to them.



THE DIAPHRAGM WHEN IT IS RELAXED

The organs from above it and below it have been removed

Place your hands on opposite sides of your body, crowd in your ribs, and come to your own conclusions as to what you have done to your lungs and to your heart. You cannot conceal the fact that you have crowded multitudes of lung cells out of service, thus



EXERCISES WHICH MAY BE TAKEN TO STRENGTHEN THE MUSCLES OF THE ABDOMINAL WALL

(After Schmidt)

robbing the blood of oxygen, and that your heart is pressed against by the surrounding lungs.

When the most important servants of the body are left to the power of the foolish hands of a woman who is ignorant about her own structure, and when these

hands give cruel treatment to servants which do her hardest work for her, is it strange that rebellion follows? Is it surprising that "liver trouble" and gas and headache and the blues and unhappiness and nervousness fill the woman with lamentation?

In the face of the fashion plates and the laced-up ladies it is a curious fact that hardly ever does a woman or a girl acknowledge that her clothes are too snug for comfort or for health. She generally assures us that they are really loose.

We ourselves may of course be exceptions; but we must remember that even slight pressure long continued is harmful.

Test yourself. Stand with your back to the wall, with head, heels, and elbows touching it. Draw a long, deep breath. Can you do this without feeling that bands, strings, buttons, or hooks are being pulled at rather vigorously? If at the same time you have no weight of clothes dragging down on your abdomen you may count yourself as well tested; you have passed the examination and may congratulate yourself that you are not preparing your body for defeat later in life. If, however, you feel the pressure of something that binds you, you need to make a change somewhere. Bands and belts should always be large enough to allow us to do our ordinary breathing without feeling that we are hampered by our clothing. When we take unusual exercise we

breathe deeper, expanding our lungs more, and our garments should be proportionately loose.

It is unwise both for growing girls and for grown women to hold their skirts in place by strings drawn tight about the waist. A yoke to the skirt is better, or skirts may be carried by straps or by waists that hang from the shoulders. In other words, weight should not be allowed to drag down on the abdomen. Learn to protect the strength and the shape of your abdominal wall by putting it under such conditions as will leave it firm and useful when you are grown. Remember that the better you can breathe and the more freely gland laboratories are allowed to do their work the better able will you be to endure the strain of life and to resist disease of every sort.

Even now multitudes of well-informed women dress according to their knowledge of these facts, and the same knowledge is spreading so fast among the young that from the signs of the times it looks as if small, deformed waists would soon be as unfashionable as are the small, deformed feet of a Chinese lady.

CHAPTER XXVII

FOOD OR DRINK FOR OKUSHIRI ISLANDERS

Okushiri is an island in the beautiful sea of Japan. It is about fourteen miles long and lies not far from the coast of the large island of Nippon.

When the events now to be recorded took place the population of Okushiri numbered about two hundred and fifty. A mere handful of poor fishermen they seemed to be, but from their obscurity and their poverty they raised themselves into fame and prosperity.

In 1884 these people were distributed in four villages. They lived in houses made of grass, supported themselves by fishing, had but four roads and but one school. Worst of all a famine threatened, for the price of food was high and their own catch of herring had been so small that year that they had little money with which to buy other kinds of food.

One thing, however, they had to comfort them in their poverty. They speak of it themselves: "The people have no other pleasure for body and mind than in the use of sake.[1] Nine out of ten of us like the liquid, and what we annually spend for the same is not small."

[1] The national alcoholic drink

To us who read about it the amount of sake which they used seems very large, for we are told that during the single year of 1884 the inhabitants of Okushiri imported eight hundred and eighty casks of sake for their own use, and had besides a goodly stock of brandy and other drinks. They intended to be well provided with this one thing which consoled them in their misery and helped them to forget their hunger.

Happily, however, there are as wise men in Japan as in other lands. And, most happily for the fishermen, one of these wise men was governor of the district of Japan to which Okushiri belongs. When, therefore, this governor made his regular visit to the island in 1884 and saw the poverty of the people, — saw that famine threatened them for the winter, and also saw how well prepared they were to comfort themselves with their sake, their brandy, and their other drinks, he gave the subject close attention.

Furthermore, he made an estimate of the size of their drink bill for the year, and his figures proved that they were spending money out of all proportion to what they earned on sake which did not nourish them, when they were in sad need of the same money for food which would nourish them.

Being a clear-headed man he had no doubt as to what should be done, and he urged the people to turn the tables immediately. He begged them to provide

for the future by saving what they were really wasting in the present.

Evidently these fisher folk had logical minds, for they gave heed to his counsel. They acknowledged that their debtors could not pay them what they owed, that some of their own number would have to depend on the government for food, and that the condition required an immediate, desperate remedy. Those who were most deeply impressed by the situation drew up a formal statement in which they said:

> We are in misery, and to save ourselves from the wretched state of things we must have recourse to some extraordinary means. Frugality is to be resorted to, and vanity of all sorts must be set aside. We, therefore, before all others will abstain from the use of what we relish more than all other things — *sake* — and thus close the way of importation of the liquid into this island. The money we should spend for it will be spent for rice and other grains, and thus we will provide for our future wants on the one hand and will increase our capital in fishery on the other.

In carrying out this determination, those who originated the plan drew up a formal document in order that they "might secure," as they said, "the prosperity of the island." They called upon all those "who like to share in our privation for the good of the public and the future" to "come speedily and sign the contract." This was in July, 1884.

The document which the islanders were asked to sign held ten different statements, which were put in

the form of a contract. Those who signed this contract pledged themselves neither to buy nor to sell alcoholic liquor of any sort for five years, and to give no aid to such inhabitants of Okushiri as persisted in the buying or the selling of it. For any breaking of the contract there was a heavy fine, and all such fines were to be spent in buying rice, which should then be hoarded in a common granary. Those who bought alcohol were to be fined half as much as those who sold it. All immigrants from other provinces were to be taught promptly about the prohibition plans of the island, and no one was to be admitted who did not understand the situation thoroughly. Such persons as bought alcoholic liquor in any form from passing ships or boats were to be taxed to the full extent of the law.

Last of all, the following statement was distinctly made:

> This contract is to be in force for five years; and when the provision for years of scarcity is fully made and each and everybody is able to lead an independent life, proper changes shall be made upon further deliberation.

One hundred and seventeen Okushiri islanders signed the contract. It was rigidly enforced for five years, and at the end of this time still other records show what the results were.

It was now 1890. Not a drunkard was left on the island. Some had been reformed by giving up the

drinking habit. Others who were too weak to change had gone elsewhere to live. Those who stayed had prospered greatly, while their numbers had increased five-fold. The money which they had put into the fishing industry had multiplied itself by ten. They had even started a new line of work, for now they raised their own hemp and made their own fish nets. Their houses were larger and better made, their schools had improved in quality and in numbers, additional roads had been constructed, and there was less crime. From being spoken of with pity by neighboring islands, as was previously the case, these fishermen were now referred to as "the prosperous people of Okushiri."[4]

The five years had certainly brought good results. Okushiri islanders were no longer a poor and miserable people. Famine did not threaten them now. Was it necessary, then, to keep sake and brandy out of the island any longer? This was the great question of the day for Okushiri in 1890. They discussed it thoroughly and answered it by deciding that for still another stretch of five years they would travel by the road which had led them to such happy results. According to last reports they were still going without alcohol and were still prospering.

In other lands those who are interested in the question of profit and loss have asked themselves whether or not it is a good investment to put money into daily

drinks of beer. They have looked into the matter quite as thoroughly as did the governor of Okushiri, and have come upon a striking set of facts. By making careful inquiry about prevailing prices in America in 1908 they found that if a person should drink three glasses of beer a day during one year he would spend on this drink alone enough to buy the following articles. They are placed one under the other that they may be read easily.

1 barrel of flour
50 pounds of sugar
20 pounds of cornstarch
10 pounds of macaroni
10 quarts of beans
4 twelve-pound hams
1 bushel sweet potatoes
3 bushels Irish potatoes
10 pounds of coffee
10 pounds of raisins
10 pounds of rice
20 pounds of crackers
100 bars of soap
3 twelve-pound turkeys
5 quarts of cranberries
10 bunches of celery
10 pounds of prunes
4 dozen of oranges
10 pounds of mixed nuts
3 tons of coal at five dollars a ton

CHAPTER XXVIII

THAT WHICH DESTROYS, AND HOW MEN SAVE THEMSELVES

On the eighteenth of December, 1902, in the city of Paris, France, a report was made by a committee of the government. The state officials considered this report so valuable that they ordered copies of it printed as posters in large black letters on a white background. In France none but state officials are allowed to print posters thus in black and white. When such appear, therefore, they are read, because they come from the government.

These posters were placarded here and there on the important buildings of the city. They were put on the walls and in the corridors of hospitals, on the streets, in the post offices, and even on the outside wall of the great Hotel de Ville, where the business of the city is carried on.

A few extracts will show what it was that the government wished to proclaim in this public way.

DRAFTED BY

PROFESSOR DEBOVE, Dean of the Faculty of Medicine,

DR. FAISANS, Physician to the Hôtel Dieu.

Alcoholism is chronic poisoning resulting from the habitual use of alcohol, even when this is not taken in amounts sufficient to produce

drunkenness. Alcohol is useful to nobody, it is harmful to all. It leads, at the very least, to the hospital, for alcoholism causes a great variety of diseases, many of them most deadly. It is one of the most frequent causes of consumption. Typhoid fever, pneumonia, or erysipelas, which would be mild in a sober individual, will rapidly kill the alcoholic. Alcoholism is one of the most frightful scourges, whether it be regarded from the point of view of the health of the individual, of the existence of the family, or of the future of the country.

Paris does not stand alone in this protest against alcohol. Through the recent revelations of science every country is roused at last. The most ambitious nations recognize the fact that they themselves are strong or weak in proportion as their individual citizens have strong or weak bodies.

This, then, explains the activity against alcohol which appears in many lands. Anti-alcohol leagues and societies comprise tens of thousands of men and women who know that alcohol is more dangerous than fire as a plaything. "Let a man know the facts," they say, "and if he is wise he will no more risk his life by drinking alcohol than by jumping into a burning building." These societies, therefore, do their work by printing and distributing facts about the effects of alcohol on body, mind, and character. And the material which they have gathered covers thousands of pages.

In Germany alone, previous to 1908, eight hundred and seventy-one books were printed which discussed

the question of alcohol. Thirty-seven newspapers, magazines, and annuals devoted themselves to the same subject; and hundreds of articles about alcohol were printed in the important magazines of that country.

The prominent men in this great German movement are the professors of physiology in German universities. Indeed, the matter has gone so far in Germany that, in 1907 one hundred leading professors in the leading universities, signed a declaration which included the following statements:

> All the prevalent ideas in regard to the invigorating and otherwise supposedly beneficial properties of alcohol in small doses have been proved erroneous by scientific research. Moderate drinking has a tendency to make the human body more liable to disease and to shorten life.

The Imperial Health Office in Berlin is sending out arguments against using alcohol as a drink; and the brother-in-law of the emperor, Count Douglas, is one of the most earnest workers in the anti-alcohol campaign. Many of these men in Germany advocate going without alcohol entirely. They say, "The abstainer alone is doing his duty."

In Sweden the royal family is noted for the number of those who practice total abstinence. It was the crown prince himself who gave the address of welcome to the great temperance gathering that met in Stockholm in 1907.

In Japan the law of the land forbids the sale of alcoholic drinks to those who are under twenty years of age.

In the United States, in 1908, over thirty-six million people in different cities, districts, and states were living under laws which prohibit the sale of alcohol in their neighborhood. The people themselves have made these laws for their own protection. Sometimes, however, there is great excitement, with danger of defeat. This was true for Indian Territory in 1905; and the history of the struggle is a sequel to the twenty-seventh chapter of *Town and City*. It continues the tale of the relation of America to the Indians and to their protection against alcohol.

For seventy-two years the government of the United States kept its promise to the Five Civilized Tribes, and without alcohol the Indians prospered so well that it did not occur to them that they could ever again be in danger from intoxicating liquors sold in public. But in course of time there was danger, and it came about in this way.

The great event for every territory in America is when it can count up inhabitants enough to allow it to be changed from a territory to a state; for when this time arrives it may send senators and representatives to Congress, and may do its part in governing the entire country as well as itself. Before this day dawns each

territory is treated as a child and governed from headquarters in Washington. We see, then, why a territory is about as proud to become a state and a voter as a boy is to become a man and a voter. Yet it was this very chance to be a state that brought the danger to Indian Territory in 1905.

For some time there had been talk about changing three western territories — New Mexico, Oklahoma, and Indian Territory — into states; and at last it looked as if Congress would do it. Naturally, of course, everything that is said or written at such a time is carefully followed by those who are specially interested. We may then imagine the astonishment, even the terror, of the Indians, when they saw that according to the proposals that were being made, the government was likely to give up all responsibility in the matter of prohibiting the sale of alcohol in their territory. In which case, after Indian Territory should become a state, any liquor dealer in the land would be quite at liberty to carry on his business there.

Not alone Indians, but white residents of Indian Territory as well, were ready to protest against this. They had gone to the place to be rid of the crime and the taxes that liquor brings, and were not at all inclined to give up their freedom without a struggle.

But the situation was even worse than at first appeared. Look at a map of the United States and notice

that Texas is south of Indian Territory and Arkansas east of it. Now both of these states had already voted saloons out of more than two thirds of their area. Besides this, other states north and east were also crowding saloons out of one district after another. The result was that thousands of those who wished to sell alcohol and thousands of those who wished to buy it had been forced out of business and were eagerly ready for the new opening.

The inhabitants of Indian Territory were convinced that if the government of the United States should cease to protect them from alcoholic drinks, many dislodged and undesirable citizens from elsewhere would crowd in like famished wolves and would try to compensate themselves for having been thrust out of other places. For this purpose, indeed, unscrupulous men were using their money and their influence to try to induce the United States Senate to break its promise. They were ready to sacrifice even the honor of their country for the sake of getting alcohol into the new state.

There was still another party at work, however. Nor was this strange, for when a great calamity threatens to overwhelm a people, all good citizens are ready to join hands for the rescue. Indians now held meetings and conferences. They worked and protested. Their white fellow-citizens sent delegates to talk with senators and with different members of important committees in

Washington. They kept the country informed as to what the danger was and how things were going. They let certain suspected senators know that if they should betray the government by voting to break its solemn promise, the honest people of the entire country would be outraged and would do all they could to prevent them from being sent to Congress again.

Among the senators themselves there were those who said that rather than have the government disgrace itself by a broken promise of this sort, they would vote against having Indian Territory become a state at all. In which case, the prohibition laws would stay as they had been.

The agitation lasted for two years. Then the senators did what was honest. They even made that part of the country safer than before, for they joined Indian Territory to Oklahoma, gave the name Oklahoma to the new state, and enacted a temperance law which will do its part in saving Oklahoma from alcohol. The following words are taken from the new law:

> The manufacture, sale, barter, and giving away of intoxicating liquors within this state is hereby prohibited for a period of twenty-one years after the date of the admission of this state into the Union, and thereafter until the people of this state shall otherwise provide by amendment of this constitution.

CHAPTER XXIX

PROTECTED BY THE SKIN

There is no doubt about the value of the work which certain scientists did in 1775. These men were anxious to know how much heat the body of man can endure and still keep at its work. For the sake of making no great blunder, they began their tests by passing from one heated room to another until they found themselves living and breathing in a room in which the thermometer showed a heat of 210° F.[1] This is but two degrees cooler than the temperature which water needs for boiling.

As may be imagined, the air of the room felt very hot. One man, however, stayed in it for ten minutes. During this time the heat was so great that it twisted and broke the ivory frames of all the thermometers but one. More than this, the air which the man inhaled was so much hotter than that which he exhaled, that, with each breath which he drew, he felt as if he were scorching his nostrils. But with each exhalation his nostrils were cooled again. He took the thermometer in his hand and blew on it. At once the mercury sank in the

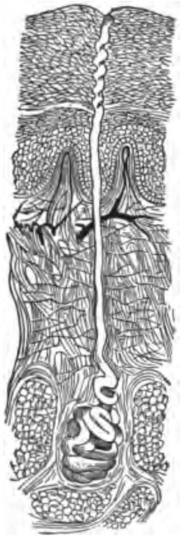
[1] Fahrenheit.

tube, showing that his breath was cooler than the room. He blew on his fingers and they were cooled too.

In another experiment afterwards, the same men went into a small room which was even hotter than any they had been in before. Here the thermometer showed 260° F. This, then, was forty-eight degrees hotter than water needs for boiling. As they entered, the air felt hot but they could bear it. And while they stayed there they did various things to show what the heat of the room was able to accomplish. They took a piece of raw beefsteak, left it uncovered, took a pair of bellows, blew the heated air across the steak for thirteen minutes, and found that it was rather overcooked. An egg was roasted hard in twenty minutes; water soon boiled and bubbled; watch chains became too hot to be touched; and rings had to be left off, lest the heated metal should burn a deep circle about the tender flesh of the finger. Leather shoes could not be worn, for the leather itself curled up and was ruined.

All this happened to their possessions, but the men themselves, although surrounded by the same heated air, were neither boiled nor roasted. They lived and breathed in the place, escaped alive, and their escape was no miracle. It was explained by the power of the sweat glands. If these small laboratories had stayed inactive, the scientists might have suffered from the heat even as did the steak. But their glands were able to save them.

As soon as the men entered the heated room the sweat glands began their work; perspiration was manufactured in quantities; it poured from the open flues of countless small laboratories and emptied itself upon the skin, whence it was evaporated. Thus perspiration kept the skin moist, and the evaporation of the moisture kept the surface of the body cool enough to save it from being cooked. Certainly the men were uncomfortable from first to last, but they did not suffer.



A SWEAT GLAND AND ITS OUTLET ON THE SKIN

The record of these experiments is given in the Philosophical Transactions of the Royal Society of London for the year 1775.

If you ever have the chance, watch the streaming, steaming backs of such men as pitch coal into the huge furnace of an ocean liner. There you will see the same work of protection carried on by these tireless glands. Their exact number is unknown, but by counting a few, in a small area of the skin, and by multiplying this number by the extent of the surface of the body, men estimate that each of us is supplied with about two million sweat-gland laboratories. All are slightly busy most of the time, but only extraordinarily busy when emergencies overtake the body.

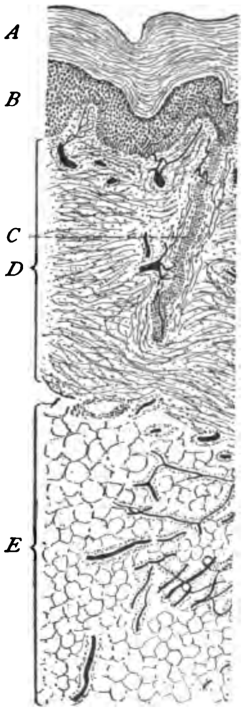
Just here review your knowledge of the skin and of perspiration as learned in *Good Health*:

1. The outside layer of the skin is called epidermis. It can be cut or pricked without giving pain. It protects all that lies underneath it, in the second layer of the skin.

2. The second layer — the dermis — holds capillaries, nerve fibers, hair cells with their muscles and oil glands, sweat glands, and pigment cells. These last contain coloring matter — pigment — which gives one boy freckles and another boy tan; which makes one man brown and another man yellow. Both nails and hair are constantly being formed in the dermis and pushed upward.[1]

3. Perspiration is a mixture of water and waste. It is poured out by the sweat glands when the body is heated or exercised. The water soon evaporates and cools the skin. The waste stays on the skin and must be washed or rubbed off; otherwise it mixes with oil from the oil glands, with bits of epidermis, with dust from the clothes and from the air, and stays like a snug, thin, perfectly fitting coat on the outside of the body from head to heel. A thick wrap of this sort interferes with the healthy action of the skin, and gives off an unpleasant smell. It may be removed by a hard, dry rub, and it is

[1] Full directions about the care of both are given in *Good Health*.



Cut through the Layers of the Skin

A, horny layer of epidermis; *B*, deeper layer of epidermis; *C*, duct of sweat gland; *D*, dermis; *E*, connective tissue in which the black lines represent blood vessels

important to take the rub whenever a bath is out of the question.

Since the skin is so well provided with blood vessels, it is natural that small wounds should heal quickly. Even when a patch of skin is entirely destroyed by being scalded or burned, there is such power of life left along the edges, that new skin grows out from it day by day until the chasm is entirely covered.

But there is a limit to what can be done in this direction, and at such times doctors step in with their wonderful help from grafted skin.

For each of us, however, there is something far more important than hot ovens, burned flesh, and the grafting of the skin. It is not probable that we ourselves shall meet these terrible experiences. But a very practical, everyday danger is always at hand. We may take cold through our ignorance of the laws of skin health and vigor. Let us therefore remember that the skin is constantly covered with a slight moisture called insensible perspiration, and that when there is

enough of this moisture to be noticed it is called sensible perspiration. The purpose of perspiration is to cool the body whenever it is in danger of getting overheated. For the sake of grasping the situation more clearly bear the following facts in mind:

1. When a man is heated from exercise, capillaries in the exercised part of the body are stretched out with the blood which is forced into them.

2. If a heated man, covered with perspiration, sits in a draft, his blood is cooled, the capillaries of the skin contract, and the mass of the blood goes to some other place.

3. When this occurs, the linings of nose, throat, lungs, and intestines are apt to be overcrowded by the blood which has been forced into them from the skin, and the most sensitive lining suffers most.

Usually the first symptom of a cold is that a man feels stuffy in nose, throat, or lungs. The explanation of the feeling is the distended capillaries, with another fact added. Although red corpuscles continue to deal with oxygen as they have always done, still the white corpuscles are now behaving strangely. They get together, many of them stick to the inside walls all along the length of the capillaries, and the more inactive they are, the less do they seize and destroy intruding microbes. These microbes, therefore, remain in the blood and continue such mischief as their nature makes possible.

When a man has a cold the trouble often is that influenza microbes have escaped the white corpuscles and have firmly established themselves in the part of the body which is congested with blood.

In view of these facts it is not hard to understand why a man who has a cold is so much more liable to take other diseases to which he is exposed. He is in a weakened condition, and already microbes instead of white corpuscles have the upper hand.

But suppose a cold is coming on, what does our knowledge of the laws of the skin direct us to do about it?

Draw blood away from the region of the cold as promptly as possible. Do it in several ways: take vigorous exercise until every sweat gland is active; take a hot bath; soak the feet in hot water; drink hot lemonade; go to bed; sleep warm; perspire freely. By keeping warm in bed the blood goes to the surface of the body, and delicate internal membranes are relieved of superfluous blood. White corpuscles are also stirred up, and restoration begins. Stay in bed until the feeling of cold is over. One night may suffice. When you leave the bed be specially careful to avoid every chance draft, for a draft just now will undo the good results of the heat treatment. Take a warm bath at once, then a quick wash with cool water. This will stimulate the nerves of your skin without chilling the blood itself, and keep you from taking cold afterwards.

If going to bed is out of the question, dress more warmly than usual, keep out of drafts, observe every law of general health, and determine to be strictly careful not to expose yourself to colds in the future.

Sitting in drafts or with damp feet, or with clothes damp from perspiration or from rain, is dangerous because in these ways the body may be chilled. A quick, cold, two-minute bath with a hard rub afterwards acts as a tonic and not as a chill to the body.

CHAPTER XXX

WORK, HEAT, AND FUEL

Let a man live in central Africa or let him travel to the coldest land; let him stay in the burning heat of his city home or wander in the cool shadows of the country; let him be in bed or in the harvest field, in the countinghouse or in the mine; wherever he is, he will find that if he is well the thermometer under his tongue always indicates about ninety-eight degrees of temperature.

In each place also, even if he is not well, the heat of his body will change but little. We say that a man has a slight fever if his temperature is 100° F. If it reaches 102° we grow somewhat troubled; if it rises to 103° and then to 104°, we are truly anxious; for no man is expected to live after his temperature has reached a higher point than 107°.

It is well for us that the body has this power to keep the blood warm independent of outside conditions; for if it were otherwise,—if we were as cold-blooded as is the frog, we should be as useless in cold weather and in cold places as he is. We should have to hibernate in winter as he does.

Birds, as well as all animals that begin life by taking milk from their parents—mammals they are called—are warm-blooded. Each has for itself this wonderful power of meeting the changes of the weather with a constant temperature of its own. As a result, such animals are generally warmer than the surrounding air, and are called warm-blooded for this reason.

Cold-blooded creatures usually feel cold to the hand when we, who are warm-blooded, touch them. Their bodies have no power to stay warm when the air is cold about them.

Although this power is part of our possession, it is nevertheless true that even the heat of our warm bodies can fail. Men do freeze to death. They cannot endure a freeze and then come out of it again, as does the cold-blooded frog. People may live in the coldest countries and be active and healthy there, but the one condition is that they help the body do its work by preventing the escape of more heat than the same body can promptly replace.

Never confuse these two facts:

1. The inside heat of the body changes little from year's end to year's end. If it changes many degrees up or down, we die.

2. The skin feels warm or cold as the air about it changes. Skin and nose and toes may freeze, but the inside temperature remains practically unchanged.

Put a dozen people in a small room, and the room grows warmer because those human beings give off enough heat to warm the air about them. In a cold country or in a cold room each body must keep within itself as much of its own heat as it can. Naturally, therefore, we wear more clothes at one time than at another. We are treasuring up our own supply of heat for our own use.

In the same matter of heat we may ask why exercise helps. Why do boys say, "It's so cold we've got to run to keep warm?" For the mere reason that when muscles contract and when blood moves fast, the heat of the body is decidedly increased. Any one who can get hold of a doctor's thermometer may test this for himself. Put it far back under your tongue and keep it there two minutes; decide what your present temperature is, then take vigorous exercise of one sort or another for twenty minutes and use the thermometer again. If you did not breathe through your mouth, you may find that you have been able to raise your temperature slightly.

Consider also that while you exercised and breathed hard you expelled quantities of warmed air from your lungs. Without doubt, then, taken altogether, your body produced a large amount of heat while it also worked. Now try to explain the source of its power to do these two things. Watch yourself at the dinner table after exercising. You have such an appetite as comes only when

you have been using up your supplies. Food is to the body what fuel is to a stove, and in a certain way your machine has been burning up its fuel while you worked and grew warm. Your appetite is nature's call for a fresh supply of food.

Sometimes active exercise leads the body to call for so much fuel that the stored-up supply, fat, is rapidly reduced. Talk this over with any thoughtful football player and he will tell you that during the football season he loses much of the fat which was stored up by the body during the previous summer. The body has need of extra fuel when it does unusual work, and it then draws on its reserved supply.

A fat man applies this power of the body to his own case. He studies himself both in the mirror and on the scales, and concludes that his body has stored up too much fuel in the shape of fat. He knows that to get rid of it he must compel his muscles to use it, and at once he begins a course of vigorous exercise which gives hard work to large muscles. They respond by calling for fuel, and if he is faithful day after day, the mirror and the scales will soon show that he is accomplishing his purpose, — that he is losing his fat.

Perhaps we wonder how it happens that although we sometimes exercise so hard as to use up much of our fuel, the thermometer shows a gain of so little bodily heat. As we learned in the last chapter, the reason

rests with the sweat glands. They are such a successful cooling device that whenever we exercise enough to raise our temperature above its normal point, they promptly manufacture their clear-colored liquid and send so much of it out upon the skin that the internal temperature of the body is kept from rising too high for safety.

The body is thus seen to produce its own heat, while it also cools itself when we overheat it. Through this power, however, we may take cold unless we know how to prevent heat from escaping too fast when the body needs it. Three rules will be useful in putting this into practice:

1. Never sit long in a room that feels chilly. A long, slow chilling of the body does even more harm than a draft.

2. Never come in heated from hard exercise and cool off in a chilly room. Either continue exercise in the room, or wrap up thoroughly. Best of all, when this is possible, take a quick cool bath and change your damp underwear before you sit down for quiet work.

3. Remember that there is little danger of harm to health, however damp the clothing may be, so long as vigorous exercise is kept up.

Whether our garments are damp or dry, however, it is always true that we are warmed not by the cold we keep

out but by the heat we keep in.[1] Flannel succeeds better than cotton in preventing the escape of heat, because more air is entangled in the mesh of woolen than in that of cotton goods, and air is a poor conductor of heat. For this reason we choose woolen goods for winter wear and cotton materials for our summer clothing.

During a long drive in the face of a sharp wind many a sensible man has slipped a newspaper under his coat. He has acted on his knowledge of the fact that paper is a poor conductor of heat, and that each separate layer of newspaper helps to keep heat from escaping from the air underneath it. In summer, on the other hand, we choose the thinnest clothing and the fewest possible layers of it. We wish to make it easy for the heat to escape.

That which we may do in guiding or in preventing the loss of bodily heat leads us to our knowledge of another fact: *We may so train the body that it will improve in the power to adjust itself to different states of heat and cold.* In other words, the body can be educated.

[1] If the body is not sufficiently covered, heat radiates from it and escapes. Cool air takes its place at once and surrounds the body as a layer. Capillaries in the skin now contract and force the blood away from the surface to the inward parts of the body. These parts then become congested, while the skin feels cold, because the contracted blood vessels can only hold a small supply of blood. By putting on extra clothing at such times and by rubbing ourselves hard, we cause the blood vessels of the skin to expand, more blood passes through them, and we are warm again.

This may be done by following the rules already given and by attending to a few other points:

1. Do not spend much time in overheated rooms, that is, in places heated above 70° F. The body grows exceedingly sensitive to cold if it is kept constantly too warm.

2. Do not overweight yourself with clothing in a warm house, nor take vigorous exercise in heavy garments. In other words, regulate your clothes to your need.

3. If you are in good health, take a quick cold bath every morning. Nothing is better for preparing the blood vessels for changes in temperature.

4. Keep the body clean by a soap-and-water bath at least once a week.

He who attends to the various rules connected with bathing, eating, exercise, and the heating of the body will find at last that he has reached the happy condition where sudden changes in temperature and unexpected drafts do not harm him as they did in former days.

The great work of hygiene is to help the body as it tries to help itself. And in this direction one of the vital points is to know how to protect living tissue from disease microbes.

CHAPTER XXXI

LIVING TISSUE THREATENED BY MICROBES

On the first of September, 1909, the board of health of the state of Kansas began to enforce a new law:

> The use of the common drinking cup on railroad trains, in railroad stations, in the public and private schools, and in the state educational institutions of the state of Kansas is hereby prohibited, from and after September 1, 1909.
>
> No person or corporation in charge or control of any railroad train or station, or public or private school, or state educational institution shall furnish any drinking cup for public use, and no such person or corporation shall permit on said railroad train, station, or at said public or private school, or state educational institution the common use of the drinking cup.

When this law went into effect, and when thirsty people arrived at the station and found that they must have their own drinking cups, some of them were displeased. They thought the board of health was growing altogether too particular. But read the following facts and judge the case for yourself. I quote the account from a report that was printed in February, 1909:

> Professor Davidson of Lafayette College asked ten boys to apply the upper lip to pieces of flat, clean glass in the same way as they would

touch a cup in drinking. These glass slips were then given a thorough microscopic examination, and they showed an average of about one hundred human cells, or bits of skin, and seventy-five thousand bacteria[1] to each slip. This from one application of the lip.

A cup which had been used in a high school for several months without being washed was lined inside with a brownish deposit. Under the microscope this proved to be composed of particles of mud, thousands of bits of dead skin, and millions of bacteria, among which were scores of germs corresponding in all details to those of tuberculosis. Some of this sediment was injected under the skin of a healthy guinea pig, and in forty hours the animal died. A post-mortem examination revealed the fact that death was due to the presence of a sufficient number of pneumonia germs to cause blood poisoning.

A second guinea pig inoculated with the cup sediment developed tuberculosis. Careful inquiry proved that several pupils in the school from which the cup was taken were then sufferers from this dread disease.

Remember these facts when you next take up the schoolhouse drinking cup or any cup used by other people. Think of the microbes which may be on it from other lips than yours and decide whether or not you care to run the risk of putting an invisible foe into the citadel of your body. Teachers the world over are beginning to take dangers of this sort into account. Instead of the cup, therefore, children are sometimes expected to drink from a slender stream of water as it comes from the pipe. Lips thus touch nothing but water, and no harm is done either to the one who drinks or to those who come after him.

[1] Different kinds of microbes.

But a drinking cup is not the only schoolhouse danger from microbes. Recall the last half of the fourteenth chapter of *Good Health.* Think of that eye epidemic in Germany which began in one schoolroom, then spread from room to room, from schoolhouse to schoolhouse, until four thousand children were suffering from it. Think of that more serious eye disease — trachoma, as it is called — which travels so fast after it is once started, and which so often threatens blindness to the one who has it. The government of the United States does all it can to keep out of the country all those who have it when they come from foreign lands. Remember that for pink eye, for trachoma, or for any other contagious disease there is but one road by which the microbes travel. They go by the road of touch. No healthy eyes will take the disease unless they are touched by something which has already touched diseased eyes.

My next-door neighbor seems to know this already. He came from school the other day and said, " Pink eye has started in school, but I 'm not going to catch it." " How will you be sure to escape ? " I asked. " That 's simple enough," he answered ; " I 'll keep my hands away from my eyes ; I 'll never touch them with anything except my own clean towel at home. I 'll have to do this because at school my hands have to touch what other boys have touched, and I never know what microbes may be on them." I commended my neighbor and was

glad to see that he did save himself from pink eye, although his best friends had it. The probability is that they not only touched their eyes with their hands but also used the common school towel. This should be banished from every schoolhouse. It provides too fine a road for such microbes as travel by touch.

And what about pencils both in the schoolroom and out of it? I once saw a healthy-looking boy borrow a pencil from his sickly-looking neighbor and touch it to his lips at once. I was frightened. Later I asked the boy if he thought it wise to pass microbes from mouth to mouth by means of the point of a pencil, and he confessed he had never given the matter a moment's thought. But he was bright enough to see that if a drinking cup can carry microbes, the point of a pencil may carry even more, for it goes directly from the lips of the person who has moistened it to those of the next heedless person who touches his tongue to it and leaves his microbes on it. The same is true for those who moisten a finger to turn the pages of the book they are reading; the habit is unwholesome as well as unattractive.

So much, then, for the direct ways by which microbes may travel from person to person; but what about the indirect road? Think of our numberless small, unwelcome neighbors, the flies and the mosquitoes. Why do intelligent people object to the presence of flies in kitchen, pantry, and dining room? Why do we carry on an

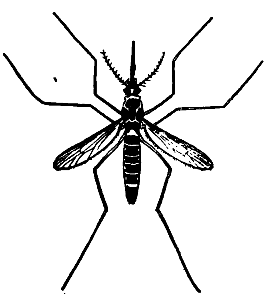
endless fight against them? For the simple reason that flies never either wash or wipe their feet. Yet think for a moment where those tiny feet travel. Where dead things lie, where filth is worst, where disease has been, there do we find flies in greatest numbers. And it is always in just such places that they lay their eggs and multiply.

Study the subject for yourself. Look at the open garbage pail in the summer, or at a pile of decaying waste anywhere. Notice the multitudes of flies there, then notice where flies stand thickest in your home. From the barnyard where they multiply fastest in horse manure, or from a sewage farm with feet covered with typhoid microbes, they may fly to your dining table and leave living microbes on bread, beef, cake, candy, — on anything you eat. For in the line of food flies enjoy not our waste alone but also whatever we have prepared with greatest care as food for ourselves. They stand on this dainty food of ours with their soiled feet, and we swallow the food plus the microbes which mark their footsteps. This danger from the fly is very real.

Of every hundred soldiers who died in the Spanish-American War twenty were killed by bullets, eighty by microbes. And over and over again the doctors blamed the feet of the flies for having put typhoid microbes on the food the soldiers ate.

But aside from their feet there is mischief done by flies through the refuse which they are willing to eat.

Dr. Lord, a scientist, allowed flies to eat sputum from a man who had tuberculosis. Those flies then deposited their flyspecks, and fifteen days later Dr. Lord examined the specks and found living tubercle bacilli in them. Those microbes of tuberculosis had been taken into the mouth of the fly, had gone safely through its body, were alive when they left the body as flyspecks, and after fifteen days they were as vigorous as ever and ready to threaten the living tissue of human beings. Think of the flyspecks which are left on our food when flies stand upon it.

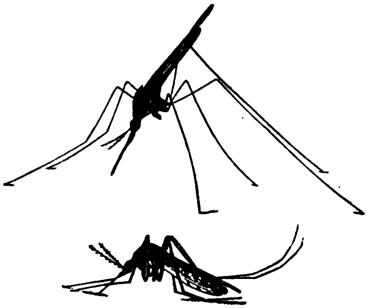


Stegomyia Mosquito that carries Yellow Fever

Turn also to mosquitoes. In 1793 within the space of six and a half weeks one tenth of the population of Philadelphia died of yellow fever. Naturally, of course, the city was in a panic. No one knew what started the fever nor how it traveled from one person to another. But, thanks to science once again, we now know that if every mosquito of a certain kind were banished from the earth to-day, no human being would ever again be killed by yellow fever. It has been proved that stegomyia mosquitoes are the only yellow fever agents in the world. By their sting, provided they themselves have already stung a yellow fever patient, they pass the disease along. Malaria is another

disease which is carried only by mosquitoes. A person who was never stung by the anopheles mosquito would never have malaria.

It is these facts, then, that explain the modern fight against flies and mosquitoes. We have no objection to the little creatures themselves, but we greatly object to the diseases which they may inflict upon us. We therefore do what we can to reduce their numbers. A careful housewife keeps the garbage pail closely covered, that flies may not enter and lay their eggs there. She has it emptied often and scalded, that such eggs as may have been laid on the food before it went into the pail may be killed and never allowed to hatch. She also keeps her food away from the feet of flies.



MOSQUITOES

Above is anopheles that carries malaria. Below is culex the common, harmless mosquito. We know which is which by the position each takes when resting

A careful city takes the same fly facts into account. It allows no piles of rubbish to stand about; it allows no dead animals to stay unburied; it insists on having clean streets and a city without places where flies may lay their eggs. All this explains the passion for clean things which now moves all civilized people. We wish to breathe clean air in clean streets; we wish to eat

clean food where no disease microbes may be found; we wish to be rid of city waste promptly because we are not willing to run the risk of increasing danger for ourselves from microbes which might threaten us.

As for exterminating mosquitoes, this is done by filling with earth all marshy places (for it is there that mosquitoes lay their eggs) and by pouring kerosene oil over open cisterns and ponds too large to be filled. Mosquito eggs and wigglers are killed when kerosene covers the surface of the water in which they live.[1]

In every city the intelligence or the ignorance of the citizens decides what their own life and death prospects shall be.

[1] See *Town and City* for an account of the war against mosquitoes in New Orleans.

CHAPTER XXXII

SPREAD OF EPIDEMICS

A certain boy in New York City had measles. He was quite ill, went to bed, called the doctor, stayed at home for some time, then was well again and went back to school. After that he became very popular. Why? Because, as Mr. Riis says, "He could pull the skin off with his fingers as one would skin a cat." And he gave the largest rolls to his dearest friends. He did not know and his friends did not know that microbes of measles are thick in each smallest fragment of skin that comes from any one who has had the measles. So the skin went from the boy to his friends. They took it home with them and divided it among their other friends.

Then came the climax of that bit of ignorance. A great epidemic of measles broke out wherever the skin had been distributed. Many were ill; some died; all suffered. If those boys, their parents, and their friends had known the facts about measles, they would have used their brains and saved their bodies from a very preventable epidemic.

The truth is, that when we say "There is an epidemic in this place or that," we simply mean that disease

microbes of one sort or another are passing rapidly from person to person, and that many have already been overcome by them. It is evident, then, that the life and death record of every village and city in the land must depend largely on what young people as well as old people know about disease microbes, and on what school children as well as doctors are willing to do to keep the microbes from spreading.

But there is another contagious disease which is far worse than measles. In the year 1854 this disease broke out on Ponape, one of the Micronesian islands. It came from the garments of a sailor who had died there of smallpox. At the time of his death Ponape had a population of ten thousand; but six months later half those ignorant islanders were dead and buried. The microbe of smallpox had slain them before they had time to learn how to protect themselves from this preventable disease.[1]

In former times people dreaded smallpox and fled from it. They knew it was contagious and realized what its results were; but they tried in vain to escape it. Though they fled they were overtaken by it; they suffered from it and carried the marks of it on their faces until they died. They were also killed by it by the hundred thousand every year. According to a careful calculation fifty million Europeans died of smallpox between the years 1700 and 1800.

[1] A full account of this is given in *Town and City*.

Then at last came relief; for in 1796 an Englishman, Dr. Jenner, learned how to save men by vaccination. Since that time smallpox has slipped into the background of the deadly diseases of the world. The explanation is that to-day in every civilized country vaccination has been adopted as a preventive. It is true that nowadays people feel so safe that they often grow careless. Even the mothers of the children sometimes forget to have their sons and daughters vaccinated. In such cases, however, the board of health of the city or town often steps in and gives commands. This was done by New York City in 1901. Without much warning smallpox had appeared in the place. People here and there who had not been vaccinated were down with the fever and were dying. Two hundred special inspectors were appointed at once, and within six months eight hundred and ten thousand citizens, young and old, had been vaccinated and the city was saved from what would have been an epidemic more frightful than that which swept over Ponape. For in a city human beings are crowded close together and microbes have a chance to spread fast.

While smallpox shows itself on the outside of the body, diphtheria takes its start within the throat. And here, also, we have a swift-moving disease which seems to fly from house to house through the power of an unseen hand. We ourselves know that in this case, too, the invisible power is a microbe which is able to kill its victim.

As happens also in any attack of diphtheria, life depends on the speed with which prevention can overtake the microbe as it multiplies. A child has a sore throat, then a fever. The doctor is called, and if he finds all the signs of the dread disease, he knows that his one hope is to kill the microbes before they can kill the child. Without a moment's delay, therefore, he uses the one great cure for diphtheria — antitoxin. He not only puts this into the body of the child who is ill, but also gives it to each person who has been anywhere near the child. Indeed, the disease itself passes so swiftly from one to another that the only safety is to use antitoxin on all alike. It not only helps cure the one who has the disease, but also protects those who have been exposed to it. In previous times about forty of every hundred who had diphtheria died of it. Now it kills not more than eight in each hundred. The difference in the death rate is explained by the power of antitoxin to save those who have been attacked by the microbe.

Last week the newspapers reported the sad case of three persons who had been bitten by a mad dog in a country town. The dog was owned by the president of a college in that town, and no one suspected danger until the dog had bitten one boy and two men. He was then caught and mercifully killed. And what of the men and the boy? The doctors in the place knew that there was hope of life for them if they could be treated with

an antitoxin which is prepared for just such cases. It destroys the power of hydrophobia microbes after they have been put into the body by the teeth of a mad dog. All three of the victims were therefore hurried to Chicago. There they were treated at a special hospital for such cases. One man had been a little slow in arriving and he alone suffered from the disease. The other man and the boy were rescued from it by the antitoxin which was given in time to save them from the microbes of hydrophobia. Perhaps no suffering is more dreadful and no death much sadder than that which comes through hydrophobia. In these days, however, even this disease is preventable. To save people from it, large cities in all parts of the civilized world prepare antitoxin and supply it to the doctors when needed.

In order to bring together the teachings of the last two chapters, they might be grouped as follows:

Avoid the public drinking cup and the public towel.

Do not rub your eyes with your fingers.

Do not touch your pencil to your lips.

Do not moisten fingers at the lips to turn a page.

Do not tolerate either flies or mosquitoes in your home. Do all you can to prevent them from multiplying in your town.

Adopt cleanliness of the home as your motto for life.

Vaccination prevents smallpox.

Antitoxin saves from diphtheria.

Antitoxin saves from hydrophobia.

Quarantine prevents the spread of measles and scarlet fever.

Thus we learn how certain diseases may be prevented. But, in addition to all else, let us never forget that the health of the body demands two great things of us:

1. That we destroy disease microbes (tubercle bacilli, typhoid microbes, etc.), before they have any chance to attack the body.

2. That we keep the defenses of the body in such vigorous condition that even if disease microbes enter, they will not conquer us but will be conquered by us.

In other words, our war against the microbe means that we do two things, and that we do them both at the same time:

1. Fortify the body.
2. Exterminate the foe.

CHAPTER XXXIII

STUDENTS, RAILROAD MEN, AND ALCOHOL

Several years ago Professor Kraepelin of Heidelberg University, Germany, did some experimenting in connection with the students of the place. He was just the one to carry on the experiments because he had already made a special study of the nervous system, and because in all parts of the world scientific men recognize the authority of his name. He himself says that he really wished to save a little of the reputation of wine and beer, for he saw that science was crowding pretty hard against every drink containing alcohol.

In experimenting with his students Professor Kraepelin always gave small doses. He knew, as we do, that those who use alcohol frequently in large doses ruin their lives hopelessly. Proofs of this are on every side, in every land. There are, however, thousands of honest people who heartily believe that alcohol taken in small doses is a help to them on all sorts of occasions. It was in this direction, therefore, that Professor Kraepelin experimented.

Various university students were eager to know facts, willing to be tested, and quite ready to drink or not to drink, according as the progress of the investigation

required. One test had to do with a man's quickness in adding up columns of figures for half an hour a day during six days. Those who were being tested without alcohol added their figures as rapidly and correctly as they could. Then the alcohol period began, and now for thirteen days these same students used the alcohol and continued to spend the half hour a day at their addition tables. The work went more and more slowly during this alcohol period until the nineteenth day. Alcohol was then dropped. The men continued to add, and there was immediate and marked improvement in the work they did. This continued until the twenty-sixth day, when they returned to alcohol, and once again there was change for the worse.

Thus the seesaw between alcohol and no alcohol went on until no doubt remained. It was clear to all that the men always did poorer work during the alcohol period and better work when they had no alcohol.

There was also the test with the typesetters in Heidelberg. Dr. Aschaffenburg carried on this set of experiments. Four skilled men were chosen. Three were in the habit of using alcohol in small amounts, the fourth acknowledged that he took too much once in a while, but all were ready to go without it now or to take it, as the tests demanded. All four men were indeed anxious to know whether they themselves could use their fingers more swiftly and accurately with or without the alcohol.

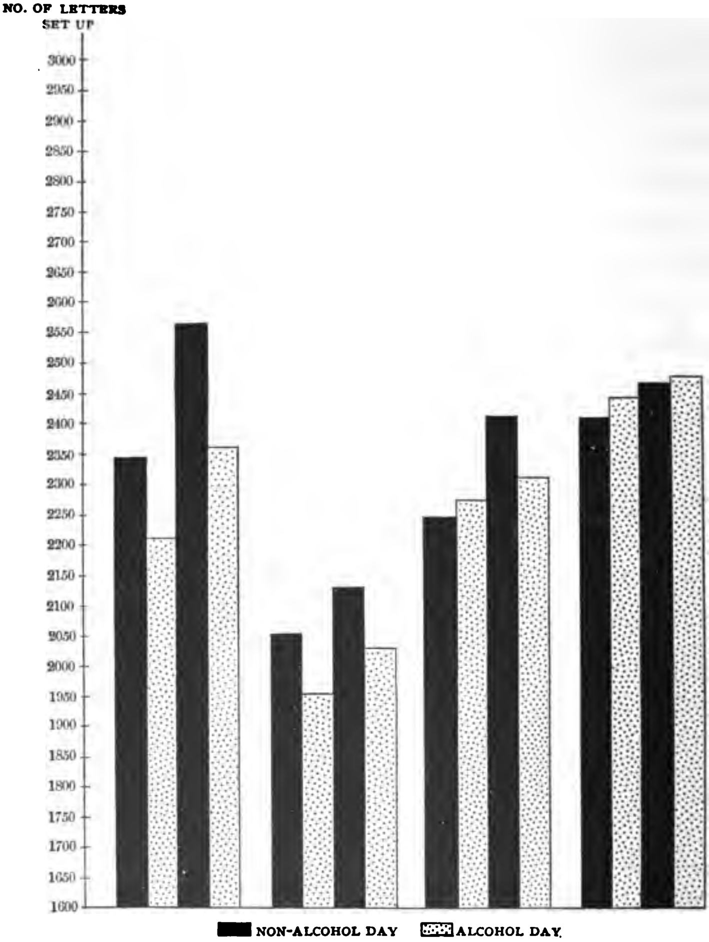
The amount which Dr. Aschaffenburg gave them on the days when they took alcohol was one ounce and a quarter; that is, the wine which they drank had about two and a half tablespoonfuls of alcohol in it.

The men drank it fifteen minutes before they began their typesetting. For fifteen minutes each day they worked hard and fast. Each did what he could to set up as much type as possible; and yet, as shown in the illustration on the next page, in every case but one alcohol hindered and did not help them.

But — and here we meet a curious fact — in every case the men themselves thought they were doing better and swifter work when they used alcohol than when they did not use it. It appears, also, that this is the usual belief of those who use alcohol. In spite of this, however, many careful experiments which have been made prove that the opposite is true.

Sweden has turned special attention to her soldiers. She wishes to know whether a glass of wine or beer taken before the shooting begins will strengthen or weaken a soldier who tries to hit the enemy.

Lieutenant Rengt Boy carried on the experiments. The soldiers selected were picked men, all fine marksmen. Their targets were two hundred yards away, and guns and rifles were used. On different days the men, in groups of six, were tested with alcohol and without it. The amount of alcohol given was about three



THE RECORDS OF FOUR MEN

Each group of four columns shows the work of the same man for four successive days. Black columns show how many letters they set up on non-alcohol days. Dotted columns show how many letters they set up on alcohol days

tablespoonfuls. This was taken in the shape of wine or beer, sometimes the night before, sometimes within an hour of the target practice; and the result of it all was the discovery that in every instance each man in each group did his quickest firing and his best hitting when he had had no alcohol whatever for two or three days beforehand, and that he did his poorest work when he had used alcohol at any time within twenty-four hours. As staff surgeon Mernetsch reports:

> When under alcohol the result was thirty per cent less hits in quick fire; and the men always thought they were shooting faster, whilst actually they shot much more slowly. When slow aiming was allowed the difference even went to fifty per cent.

With these facts in mind we are not surprised at the present great anti-alcohol movement among railroad companies. By their own experience they know that alcohol reduces a man's chance to do his best and quickest work either with muscles or brain. Consequently, all over the country railroad companies have become what might be called huge temperance societies. They are determined to protect their men from alcohol, for the sake of protecting passengers from disaster, cars from being wrecked, and money from being wasted.

In 1908 the Baltimore and Ohio Railroad Company issued the following notice:

> Officers and employees will take notice that there will not be employed, nor permitted to remain in service in the capacity of trainmaster,

dispatcher, operator, engineer, fireman or trainman, yardman, block or other signalman, watchman, or in other positions where in any way charged with the direction or operation of trains, persons who use intoxicants, either while on duty or off duty. Under no circumstances will exceptions be made.

A number of railroads forbid their men to use alcohol while on duty and say that "their habitual use, or the frequenting of places where they are sold, is sufficient cause for dismissal."

Indeed, this movement against alcohol has gone so far that the Anti-saloon League Year Book for 1909 quotes the case of what is called "the largest temperance movement any one business concern has ever known." This was in connection with the Northwestern Railroad, when twenty-five thousand railroad employees signed a monster temperance pledge. It seems that not long before the railroad had been reducing its working force for the winter. When this was done the employees noticed that every one who was cut off was a drinking man, and that all those who never drank alcohol in any shape were retained. The railroad officers even went so far as to declare that in future their plan would be never to turn off a man who was a total abstainer. This, then, was what stirred the men to action. They all wished to keep on earning money, they wished to run no risk of being dismissed from work because of alcohol, and for this reason it was that twenty-five thousand of them signed the temperance pledge.

Evidently, both for the men and for the railroad company, going without alcohol was decided on simply as a good, common-sense, business investment. In other words, sensible men saw that alcohol damaged their nervous systems and made them less efficient. They therefore used their brains, saw what should be done, and did it. The nervous system and the brain are, in point of fact, the center of all bodily activity, all thought, and all sensation.

CHAPTER XXXIV

NERVES THAT UNITE MUSCLE AND BRAIN

If a cat felt no unpleasant sensation when he needed food, he would never bestir himself from a comfortable nap for the sake of eating. If a mouse felt no unpleasant sensation when the claws of a hungry cat were hooked into his skin to seize him, he might allow himself to be caught and eaten without a struggle. If human beings felt no discomfort in the coldest weather, they might carelessly let themselves be frozen to death.

So it is on every side. All along the way we go, our sensations are our best protectors. Indeed, during each day of our lives our animal kindred and we ourselves travel through life over a road that is guarded on either side by what might seem to be a hedge of nerve warnings called sensations. The sensations themselves are of many kinds — hunger and thirst, cold and heat, headache, toothache, stomach ache — ills of a thousand different sorts. But through each separate one we learn at last that by giving heed to our sensations — to those that are disagreeable as well as to those that are agreeable — we do much to preserve our health and to make the pathway of life delightful.

Before the microscope was invented even the wisest men were obliged to do much of their scientific work by guessing. They first imagined that each nerve was a tube filled with something exceedingly fine and delicate, called animal spirits. The stuff, they said, was neither gas nor air, but something far more subtle than either. They thought that by means of this substance every nervous system did its feeling, moving, and thinking.

Later, other men supposed that the contents of the nerve tubes was something heavier than gas, and they called it nerve juice.

In recent times, however, the microscope has done as much for nerves as for microbes. It has destroyed numberless old-fashioned theories, and has shown that nerves are not tubes at all, but that they are a system of fine fibers which carry stimuli and messages back and forth between the body and the brain. These fibers look like slender threads. They run from the brain to the spinal cord, from the cord to the muscles, then from the muscles up again to the spinal cord and the brain. Just under the skin these fibers cover the body in a close network, and it is through their aid that living beings think and feel and move.

More than this, it is well to know that nerve fibers are divided into two groups which do two kinds of work. One group carries stimuli to the brain from skin, eye, ear, nose, tongue, and from all the internal organs of

the body. The other group carries commands from the brain to every point in the body that needs directing.

When a baby sees a flame, laughs with joy, thrusts his fingers into it, and pulls them out again with a scream, several sets of fibers have been at work:

1. One set, from the eyes, compelled the brain to see a lovely color.

2. Another set brought word from brain to hand muscles, "Feel of it."

3. A third set carried a stimulus to the brain, which seemed to say, "Something dreadful is happening to the fingers."

4. A fourth set brought the prompt command, "Pull the fingers out of the color as fast as possible."

In the meantime other groups of fibers set other muscles to work, so that at one point the baby opened its mouth to laugh with joy, and a moment later opened it again to scream with pain. Still other fibers commanded the heart to pump faster and send more blood to the excited head. They commanded the tear glands to manufacture salt water with incredible speed and in great abundance. They set lungs and vocal cords to work, too. And as the result of so much stimulation sent up to the brain and so many commands sent down from the brain, we end with a nervously exhausted, screaming, red-faced, tear-stained baby, rather a dejected-looking living machine.

If we could ever follow any series of messages up and down, we should learn to understand how swift their flight is. Stimuli from remote regions of the body fly upward to the brain, and there, in what is really the great central station, the various kinds are recognized and attended to. Commands are issued at once, and each of these now goes by its own road downward to the spinal cord. From there it is flashed across an unbroken long-extended fiber to a toe, or a finger tip, or to any muscle of the body that is to be controlled by it.

ONE SET OF FIBERS AT WORK

ANOTHER SET OF FIBERS AT WORK

The longest fibers are those which carry an impulse from the toe up into the backbone, and that bring commands back over the same distance. In a tall man these fibers, carrying messages in one direction or the other, may be four or five feet long.

If by any clever process we could separate the nerves of a man from the rest of his body, if we could turn each one of these nerves into something stiff and firm, and then could stand the entire group on a pedestal in precisely the shape which it had when it did its work in the body, this network of stiff nerves would be so delicate and so closely woven together that we should be able to follow perfectly the outline of the man to whom it belonged. We should know his height, the breadth of his shoulders, the size of head, hands, and feet; while at the same time we should note that on certain parts of his skin the network was finer and more intricate than on other parts.

NERVES THAT SHOW THE OUTLINE OF THE HUMAN BODY

If, going further, we should cut that nerve figure open, we should find other great clusters of nerves that showed the outline of every separate organ of the body.

Having seen all this, unless we know the facts of the case, we might give a thousand wild guesses as to what

this wilderness of nerves was for and how it was ever able to control the sensations and the movements of a human being. Some knowledge of the working of the brain will help explain the difficulty to us.

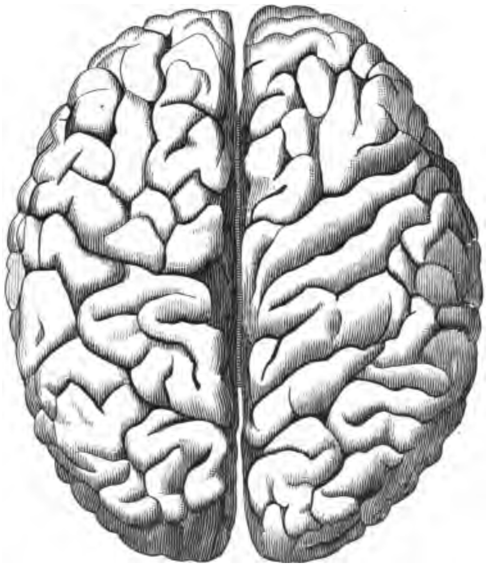
CHAPTER XXXV

THE CENTER OF CONTROL — THE BRAIN

Dr. Howell, in his physiology, describes the case of a dog who met with misfortune, lost the upper part of his brain — the cerebrum as it is called — and led a singular life ever afterwards.

Those who were studying the case kept the dog alive a year and a half, and they saw that although the animal did not suffer actual pain, still he did not know enough to feed himself; he did not even recognize his food when he saw it; he showed no pleasure when caressed nor any fear when threatened. Not a trick that he had ever learned did he now remember. And as for burying bones for future use, there was no thought of such a thing. Indeed, from the moment he lost his cerebrum until he died he seemed to do no thinking whatever. Memory was so entirely gone that he recalled nothing that he had ever learned. Formerly he had been a clever and sprightly dog, remembering old tricks, learning new ones, stealing bones and burying them, frightening cats, loving his friends and fighting his foes; but from the moment he lost his cerebrum all was changed. Henceforward he was dull, inactive and uninteresting.

In man the cerebrum is even more important. He may lose part of it through disease or accident and still be able to live and think; but if he loses the whole of it, he dies. If it is injured, he suffers in various ways. We have thus come upon the region of the brain that is most vitally connected with our thinking, with our activity, and with our power to judge what is best for ourselves.



THE HEMISPHERES OF MAN'S CEREBRUM, THE CENTER OF CONTROL

This constantly active and most important part of the nervous system lies just under the skull. It is the largest division of the brain, is separated into two halves called hemispheres, and the two together make up what is called the cerebrum.

If you ever have a chance, take in your hands a human brain that has been preserved in alcohol, and let a doctor describe it to you. First of all, however, you will notice that the substance itself looks like nothing so much as

a neatly folded, closely packed mass of gray putty, so lifeless and so uninteresting that you may feel like exclaiming:

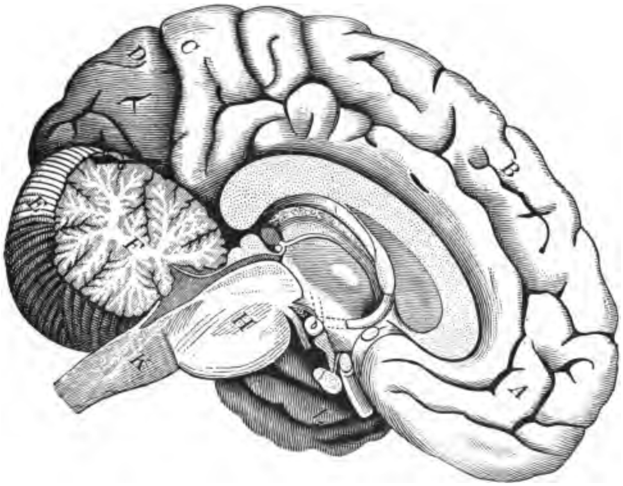
"Is this the great commander in chief of the body of man! Is this queer-looking stuff the basis of all my thinking and my feeling!"

But let the doctor hold it and explain it to you, part by part. Watch his eyes; listen to his voice as he does it; for they will tell you that to him this lifeless mass is interesting in every smallest division. He will press one part away from another at the surface and you will see that although each can be separated slightly from its neighbor, still all are firmly held together at the center. In his enthusiasm the doctor may also mention one long scientific name after another, each belonging to its own special brain division. But if he is wise he will tell you that for the present you are to remember but two of the names — cerebrum and cerebellum.

He will probably mention them in that order, for the cerebrum is larger and higher up, a soft gray cap it seems to be, folded closely in deep creases, overlapping everything below it. Nevertheless the cerebellum is in sight just beneath, at the back of the head. This too is folded and wrinkled and gray.

It may be that you will ask some questions about these deep creases in both cerebrum and cerebellum; and it may be that the doctor will flash back his swift answer,

"The more wrinkles, the more wits," for that states the case concisely. "But what good do the creases do?" you ask again. "Give more surface for the gray stuff to be spread over," comes back the answer quick and positive. And



A CUT THROUGH THE BRAIN

A, *B*, *C*, *D*, *L* show folds in the cerebrum; *E*, *F* show the gray and white of the cerebellum; *K*, *H* show the upper divisions of the spinal cord

that answer leads the doctor up to the point of his greatest enthusiasm, the gray and white substance of the brain.

Gray is all you have seen thus far, for it bends in and out with every fold and crease as if the whole substance of the brain were solid gray. "But look here," exclaims the doctor, as he presses open a deep cut which he has made with his knife through the gray cap, "see how

little gray there really is; only an outside layer about an eighth of an inch thick, and thinner than that in spots. But every thought you have, every pain you feel, every plan you make, every hope that thrills you, every purpose and ambition of your life is intimately connected with this thin gray layer that covers the white substance below it."

While you are thinking this over in amazement he will probably go on to say that the injury or disease of any part of that gray layer of the brain may rob you of one sense or another, or even destroy your brain power in the very direction where you thought you were strongest.

"If this particular brain had been injured here," the doctor will say, pointing to a certain spot on the gray surface, "its owner would not have been able to recognize anything that the eye looked at. And this is the worst sort of blindness, for when the sight center of the cerebrum is gone a man cannot so much as remember what seeing was like."

Accidents to the brain have taught some of these facts; diseases of the brain have taught others; while the study of the brains of animals has let in a flood of light on the whole subject. So that at the present time scientists know that a definite part of the gray layer is active for each separate sensation and for the power to move each separate part of the body.

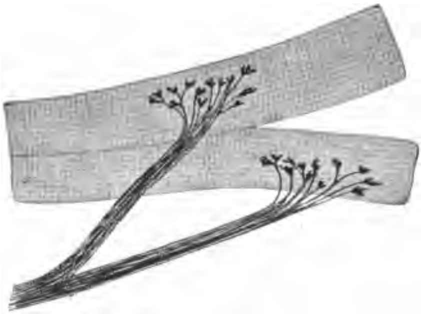
This layer is called the cortex, and cortex means bark. It is clear then that the gray bark that covers both cerebrum and cerebellum is the most precious part of the human body. For this reason it needs a stout protection, and it gets it in the firmly knit, sturdy skull which surrounds it.

Instead of being a snug fit in its case, there is a little space filled with liquid, which separates the brain from the skull.

CHAPTER XXXVI

NERVE MACHINERY

From what looks like the confused tangle of fibers under the skin it would seem as if messages might sometimes get lost on their journey,—as if those intended for one particular spot might find themselves delivered at the wrong place, bringing despair to the brain. But this never happens. The confusion is only apparent; it is caused by the way the bundles of fibers are variously bound together.



NERVE FIBERS THAT END IN MUSCLE
(Highly magnified)

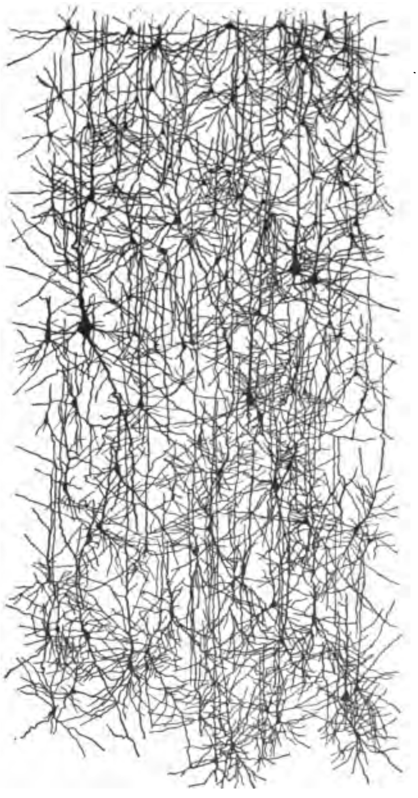
If we had eyes keen enough to see the fibers themselves, instruments delicate enough to do the work, and hands steady enough to use the instruments without tearing the fibers, we might unwrap them, bundle after bundle, and trace them from start to finish. We should then find that every white nerve is a bundle of nerve fibers, each one of which is neatly and snugly wrapped by a fatty covering

that makes it look white, and that the difference between large nerves and small nerves is quite the same as the difference between large bundles of telephone wires and small bundles of wires, for in each the number of separate strands explains the size.

As we studied the nerves in this way we should discover for ourselves where the largest ones are and how they are related to the backbone. We should see that the bones of the back are so ingeniously locked together that a round opening is left on each side of each vertebra, and that as there are thirty-one vertebræ there must be sixty-two openings in all. We should then notice that the largest nerves of the entire nervous system are these sixty-two spinal nerves which find their way to the body through the backbone; and we should see that as soon as each leaves the bone the dividing begins. Large bundles, from the cord, become smaller through their dividing, then still smaller; they hold anywhere from two hundred to twelve hundred separate fibers; they continue to divide and subdivide, so that fibers which started in the same bundle are soon widely separated.

Often these fibers pass out of the wrappings of one bundle into the wrappings of another. They do this so constantly that these various bundles, as they grow smaller, are joined together like an intricate network. They twine and intertwine, but not a fiber loses its way. Each tiny one of the millions that form that lacework of

fibers is a continuous path from some definite point on the skin, or from some muscle or gland, to some definite point in the spinal cord; and so long as no accident or wound cuts the nerve in two the stimulus which each may receive will travel straight and true from the point of the body where that fiber is stimulated, to the spinal cord, which will send the impulse on to the brain by other fibers.



WHERE THE STIMULUS GOES. INTERTWINED NERVE FIBERS IN THE CORTEX

Notice the countless nerve fibers which run up and down and crosswise (highly magnified). — After Kölliker

But accidents are frequent, and they teach scientists wonderful facts about those long-armed nerve fibers. One of these facts is that nerves are useful or not according as they remain unbroken. Think of the burning baby fingers. His nerves of feeling and nerves of motion were in good running order; he felt pain and could pull his hand

away; but if a certain set of fibers had been cut across so that the connection was broken, no stimulus would have reached his brain. The baby could then have left his fingers in the fire until they were burned off without feeling the slightest pain. If, on the other hand, a different set of fibers had been cut, no command could have reached the fingers from the brain. The baby would have suffered frightful pain, but he would not have been able to move his fingers back or forth to get out of trouble. His arm muscles would have had to come to the rescue of finger muscles and pull the hand away.

If both sets of fibers had been cut the baby would not have felt any pain, nor would he have been able to move his finger. But the burning would have gone on just the same.

The impulse which passes over a fiber is always truthful if that fiber is uncut and uninjured from end to end; but if damage has been done strange reports may reach the brain. Old soldiers testify to this. One of these men lives near my home, and when we met the other day he said: "Is n't it strange, my leg was cut off over ten years ago, but last night the heel of that foot itched and pained me so that I thought I should go crazy." "What did you do?" I asked. "Put a hot-water bag against the stump, warmed the thing up, and finally got relief." Of course he knew as well as I did that something was irritating the live ends of the fibers that used to send reports from the heel to the brain, and that when the brain received

the stimulus it had no way of knowing that the fibers had been cut in two and that their extreme ends were no lower down than the knee. The thinking and seeing part of my friend's brain did certainly tell him the truth. He knew that there was no heel there. Nevertheless, even that knowledge could not change the reports which faithful fibers were bound to send to headquarters in the brain. Something was out of order in their neighborhood, and they clamored for help until it came in the shape of a hot-water bag.

From all this it is evident that nerves and brain and muscles are pretty closely connected. The connection is indeed so very close that scientists have perhaps given more attention to the nervous system than to any other part of the body. By doing this they have discovered that nerves are really much more complex than they seem at the first glance we give to them. In point of fact a microscope in the hands of a trained scientist tells strange secrets about all nerve substance. I shall state a few of these hidden truths in a straightforward, matter-of-fact way:

1. Just as muscles are made up of muscle cells, so too is nerve substance made up of nerve cells.

2. A nerve cell has a central body with arms reaching away from it.

3. Each separate fiber in any bundle of nerve fibers is the long arm of some nerve cell.

4. The center of the cell — the cell body, as it is called — has a gray color. The arms of the cell look white because they are wrapped about by a white covering.

5. The cell bodies of the nervous system are located in the cortex of the brain, in the center of the spinal cord, and in the ganglia.

6. A ganglion is a group of nerve cells unprotected by any bony covering. There are important ganglia in different parts of the body.

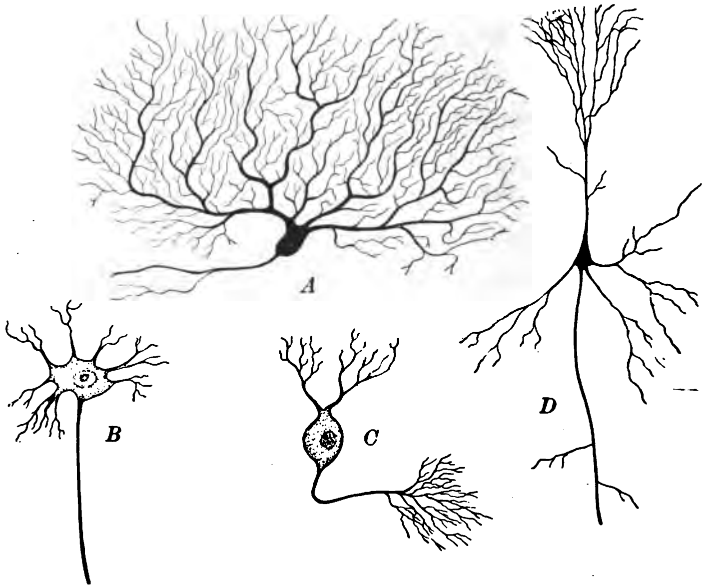
7. Nerve fibers carry stimulus to the spinal cord. There other fibers from other cell bodies receive the stimulus and hasten it on to cells in the cortex of the brain. These cells then send down commands and messages by other sets of connected fibers which stretch away to this part of the body or that.

Wherever cell bodies are clustered, whether in brain, spinal cord, or ganglion, there we have that interesting place, a nerve telegraph station. It resembles a city telegraph station in two ways:

1. It has fibers that do the work of wires and connect the central station with different points here and there. These carry messages hither and thither.

2. If a fiber is separated from its own particular cell in that central cluster it is as useless as is a telegraph wire after it has been separated from its telegraph station.

We see, then, that the vital part of each nerve cell is the gray cell body, and we realize why it is that a cluster of hundreds and thousands of these cells becomes one of the most fascinating centers of activity in the world.



Four Nerve Cells

A and *C*, from the cerebellum; *B*, from the spinal cord; *D*, from the cerebrum. The cells *A* and *D* are stained so that the main body and the fibers are black. *B* and *C* show what is called the nucleus; every nerve cell has a nucleus

Especially so as it appears that each fiber that enters the central station is responsible for one sort of message alone, and that it can never carry a message of any other kind.

Since the two sets of fibers carrying messages in opposite directions are so close together, the ignorant person might wonder whether or not any mistakes are ever made in the work they do. The answer is, that this never happens. Never in a single instance does any fiber in any bundle carry a message the wrong way or exchange its message for that which a neighbor fiber is carrying. The reason is that each fiber is separated from all the others by its own particular outside wrapping.

And now we understand the gray and white substance of the brain. The gray layer is a mass of millions of cell bodies packed together and joined to each other by white-covered fibers.

The white stuff is a compact mass of fibers, each one of which stretches away with its silvery sheath from its individual cell in the gray layer. Millions of these fibers join one part of the brain with another part of the same brain. Still other millions go downward towards the spinal cord, and there, within the firm protection of the backbone, impulses of every sort fly upward to the brain, while at the same instant, on separate roads, countless commands go from the brain to the muscles of the body.

CHAPTER XXXVII

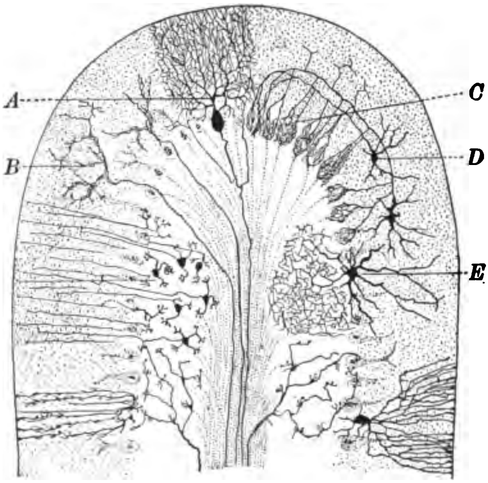
TRAIN THE CEREBELLUM

A famous scientist named Flourens once noticed that although a pigeon with a useless cerebellum does not suffer pain, it does nevertheless have the greatest difficulty in standing and moving about. He saw that when it moves, the muscles do not pull together in orderly fashion, but rather in an independent, helter-skelter way, each muscle, as it were, pulling for itself without reference to any other muscle, so that instead of walking the poor bird turns one somersault after another in rapid succession.

Dr. Flourens also noticed that the less the cerebellum is injured the less the pigeon is troubled with these disorderly movements, although even then it walks in a staggering, drunken way. It appears, however, that such pigeons may slowly learn to control their muscles again, and that after a while they are able to walk and even to fly once more; but they never do it so well as before.

From these and other facts which they have gathered, men who study the subject conclude that the cerebellum is an enormous help to the cerebrum in the matter of controlling such muscles as we are able to guide by our own will power. They say that while the cerebrum is the

commanding general of the nervous system the cerebellum is the chief of staff, the one that helps take charge of numberless movements which we have learned to make through persistent, diligent practice. When we were babies and learned to walk we thought about each step as we took it. If our minds were diverted, if certain special thinking nerve cells stopped attending to our footsteps, we tumbled down instantly. For weeks, and even for months, we hardly dared to walk alone.



CELLS IN THE CEREBELLUM
They guide our unconscious movements. *A*, *D*, *E*, cell bodies; *B*, *C*, fibers. — After Ramon y Cajal

To-day, however, after years of practice we walk everywhere without giving a thought to any separate footstep. We even step so fast that we run and dance; we ride the bicycle and we swim. Indeed, we do all this so well, and we are able to think of so many other things while we use our feet and hands vigorously, that it looks very much as if they had become quite independent of the brain. This, in fact, explains the whole situation. Their movements

have at last been put in charge of a different set of nerve cells. The happy part of this arrangement is that the particular nerve cells which do what we might call this underground managing for us are, as a rule, more trustworthy than those which help our conscious thinking.

The same law and the same power of the nerve cell holds good in other directions also. What trained baseball player stops to think of each separate run and slide, how to hold the bat; how to pitch the curved ball, how to catch it? He simply takes his place to play the game; he trusts his trained nerve cells to help him, and he finds that almost unconsciously he makes the right motion at the right instant, that he plays the game even better than he could tell another how to play it.

This is quite as true in still other lines of life. I know a fine young fellow, a freshman in college, who has lately taken up a noticeable practice. Often when he stands still, and even when he walks, he may be seen suddenly to straighten his neck and press the back of it firmly against the inside of his collar. Why does he do it? For the simplest of reasons. He believes that his head bends too far forward to be creditable, and he has made up his mind to put his neck muscles in charge of a new set of nerve cells. Every time he thinks about it, therefore, he sends imperative orders to those muscles. They straighten his neck promptly and he gets his head up where it belongs. He knows that each pull in the right

direction helps train a certain set of nerve cells, and that if he is able to persist long enough he will finally get them so well trained that they will end by making the muscles hold his head up all the time without any conscious thought about it on his own part, and that this will relieve his mind for other affairs.

When we are teaching ourselves new lessons the time for encouragement is at the first sign that we are doing the desired thing unconsciously. For example, we may be training various sets of nerve cells to help us in definite ways — to walk like a soldier, to sit erect, to talk in a low voice, to hold knife and fork and spoon as we should, to recite the multiplication table, or to repeat a poem; and day after day we may be discouraged by the fact that as soon as our own thought is off the subject we fail in our struggle; but, without warning, some day the moment for encouragement will come. We shall find that we have done the desired thing as we wished to do it, even while we were not thinking about it, and by that sign we shall know that we have reached the turning point. By being persistent a little longer, those particular nerve cells will have their lesson by heart, and the fight will be won.

This method of training is admirable for any set of nerve cells which we wish to press into service, but, even when we are not training them on purpose, our nerve cells often get trained in spite of our real desire. As an example, think of those which control the muscles of the face.

When you are glad or sad some day, try to catch the exact expression of your face in the mirror, or look at the face of some one else who is happy, or angry, or suffering great pain. In every such case you will find that, unconsciously, the muscles tell a plain, straightforward story.

The truth, of course, is that almost every feeling we have may express itself in the face, and that each repetition of the expression is one more lesson for the nerve cells which control those muscles to learn. The sad man, the worried man, the happy man, the hopeful or discouraged man, each has his own telltale face muscles; and a good student of human nature learns to read these faces almost as easily as if they were the pages of a book spread out before him.

As might be expected, it is old rather than young faces that most easily betray their owners. I myself am old enough to know this from my own observation. I have seen a fair, smooth child's face change little by little into the strong, courageous, unselfish face of a man who is ready and glad to do his duty whether he likes it or not. And I have seen another face, equally fair, equally smooth, and equally young, turn little by little into the dissatisfied, weak, and sneering face of a man who never serves any one but himself. Without planning for anything of the sort, with no idea of what was happening to him, each of these men has trained his nerve cells; and they tell the truth about him even when he might prefer to have them

tell a different story. It is evident, then, that every young face is shaping itself to the expression it will have later; and that the time is sure to come when the tale of our inner lives will be told by the outward expression of face and manner. When that time arrives we may long to hide the facts about the history of our emotions. But we shall find that we cannot cheat the nerve cells. Instead, the story which they have been trained to tell will proclaim the facts about us whenever and wherever we show ourselves.

In this chapter we have laid bare four great laws:

1. He who wishes to do any sort of muscular work easily and well, and so thoroughly that it cannot be forgotten, must, by diligent practice, put that special business in charge of its own set of unconscious nerve cells.

2. Nerve cells are often so quick and clever that they learn that which we would much rather they would not learn; and they proclaim the truth even when we wish them to hide it.

3. If we wish our nerve cells to declare that we are courageous, kind, and sincere, the only way to make them do it is by being courageous, kind, and sincere.

4. He who pretends to have desirable qualities when he really lacks them will find that, through the power of his nerve cells, in spite of his desire, he actually declares to those whom he meets that it is all mere pretense.

CHAPTER XXXVIII

TRAIN THE NERVE CELLS OF THE SENSES

A friend of mine whose senses are all in good working order is developing two of them in a delightful way. He thinks he is simply studying birds. This indeed he does, but while he studies his birds his eyesight grows keener in its power to recognize them, while hearing also grows more trustworthy; and the outcome of it is that almost never does a bird fly overhead within sight or sound of him but he recognizes it at once.

Sometimes he knows it by the way it flies; sometimes by the color of wing, breast, or tail; sometimes by its shape; sometimes by its size. Whatever the mark, in a flash, when he sees the bird, he knows it and names it. Others who are with him may have seen nothing but a bit of color passing by, or a small shape on a swaying tree top; but he has seen all that the trained eye can see, and he is able to give the color or the shape its own definite name.

What he does not see he often hears. He sits under a wide tree, and with every bird song that reaches him, every twitter, every call or cry, he names the bird. He will also tell you whether it is singing to its mate on the

nest, or talking to its young, or giving a warning cry that danger is near.

This college student keeps a record by name of all the birds he sees or hears. It is now early June, and already, since January, his roll call includes one hundred and seventy-three different birds. Some he has recognized by sight, some by sound, but neither eye nor ear could have named them save as each sense was trained to do its work.

Whether a man watches birds, or collects stamps, coins, or pictures, whether he is blacksmith, preacher, carpenter, lawyer, merchant, editor, sailor, or newsboy, he will find that trained senses lead to the promised land of success.

Men in all countries have discovered this for themselves. We are told[1] that natives in central Australia know every bird track and every beast track by sight, and that this knowledge does not come to them through any accident. It seems, indeed, that from earliest childhood Australian boys and girls are taught to notice tracks of all sorts, and that at the same time they are also taught to imitate these tracks with their fingers in the sand.

The result is that a full-grown, experienced tracker, as he is called, can follow obscure tracks which we should never notice, and can recognize them even as he rides past rather swiftly on the back of a horse.

[1] Related by Baldwin Spencer and F. C. Gillen.

But eyesight and touch do not stand alone; the power to smell may be trained too. Think of the Indians in Peru. Dr. Carpenter says that in the darkest night these people can tell, by the smell which reaches them, whether a stranger who approaches is an Indian, a European, or a negro. For them, as for the others, it is a trained sense that does the work.

We see, then, that the same law is true for all sorts of people, in lands however far apart. Everywhere he who wishes the keenest and the surest sense of sight or sound, taste or smell or touch, may secure it by close attention and constant practice.

The encouragement is that by giving ourselves training enough we shall secure the thing we desire.

Along with all these facts it is important to remember that each separate sense depends on the work done by three parts of a delicate piece of machinery:

1. Apparatus which receives stimulus: eye, ear, nose, skin, etc.
2. Fibers which carry the impulse.
3. Cell bodies in the cortex which recognize the impulse when it arrives.

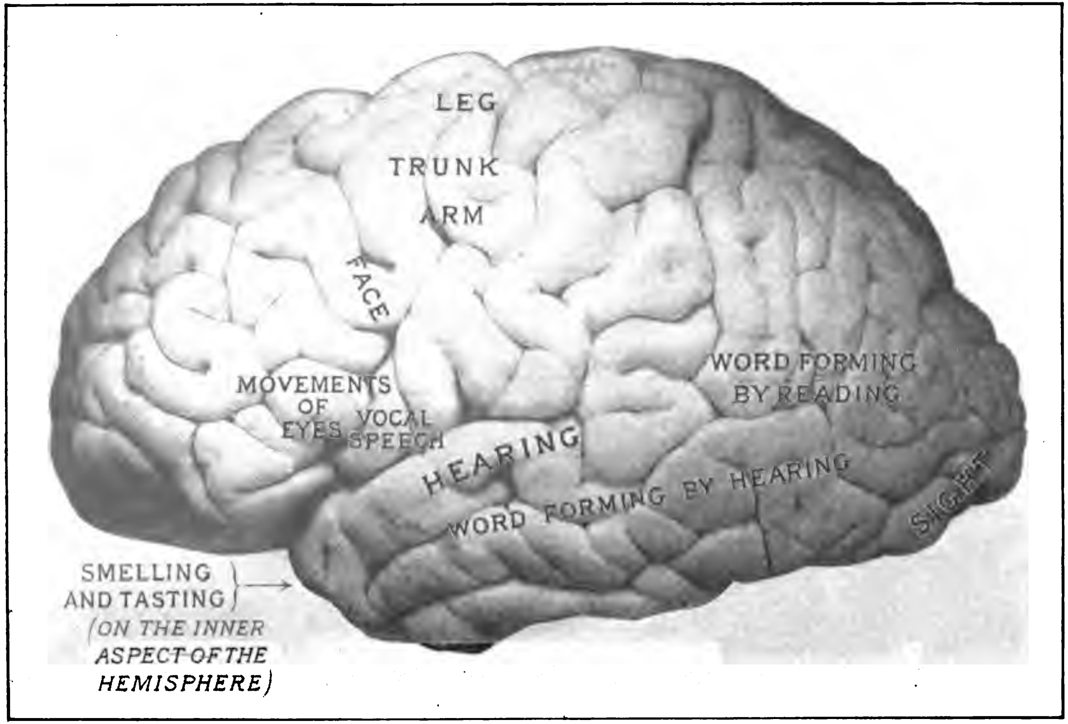
In the case of each sense, also, we must suppose that the outside apparatus itself knows no more about what is happening to it than the mouthpiece of a telephone knows what we say when we speak into it. In point of fact the receiving apparatus of each sense is nothing

more than a marvelous device for receiving its own special kind of stimulus. Ear apparatus receives a stimulus, and when that stimulus reaches the brain by way of ear fibers we say we have heard something. Eye apparatus receives a stimulus, and when that stimulus has reached the brain on eye fibers we say we have seen something. Skin and nose and tongue serve us in the same way. Each is a piece of apparatus that receives stimulus of its own kind and sends it up to the brain on its own distinct set of fibers. In every case the brain is the receiving point; the cells up there feel our sensations for us.

Since we know these many and various facts, and since we also know that exercise always develops any part of the body that is used vigorously, we are not surprised to hear that by examining a brain after death a trained scientist can tell just which set of nerve cells did the most work during life.

These men may, for example, take a bird that has lost its life, and point to a certain place on the brain. "You see it is very much enlarged," they say. "That is the part that always had the most exercise. It is the sight center of the cortex." And at once we call to mind the stories we have heard about the carrier pigeons and other birds, — about the keenness of their vision and the distance they can fly from home.

The brain of a dog may be examined next. "There!" the scientist exclaims, "do you see this part? It is the



THE LEFT HALF OF THE HUMAN CEREBRUM

The words "leg," "trunk," "arm," "face," are printed over the centers that control the corresponding parts of the body. Other words show where different sensations and memories are located

center for smell, and it is always greatly enlarged in dogs." And now we recall all our dog stories. We remember that a bloodhound will trace a man through a crowded city, that the scent of a dog is one of his most remarkable points.

The examination might go on from brain to brain, from animal to animal, each showing that one of the senses was more highly developed than any of the others.

In human brains, however, affairs are generally better balanced, unless there has been some great affliction during life. This was true of Laura Bridgman. She was deaf and dumb and blind and had no sense of smell. Her one connection with the world was through her sense of touch. As a result, the nerve cells of touch received constant daily exercise, while the nerve cells of all the other senses received no exercise whatever. Then came the startling discovery; for after Laura Bridgman died her brain itself told the story of her senses. Doctors examined the cortex and found that it was thinnest at the centers of seeing, hearing, tasting, and smelling. More than this, as might have been expected, the doctors also found that the touch region of Laura's brain was wonderfully developed.[1] In view of all this we draw the following conclusions for immediate use.

1. Although the outside apparatus does nothing but receive stimulus of one sort or another, still, if

[1] Much more is told about Laura Bridgman in *Control of Body and Mind.*

it is ruined by disease, accident, or careless use, no amount of striving on our part will restore it to us.[1]

2. If the apparatus of one sense has been wrecked, the other senses may be so highly developed as to help make up the loss.

3. Persistent exercise of any sense will increase the thickness of the part of the cortex to which it belongs.

Although no examination of the cortex of our own cerebrum is possible while we are alive, still we may have the comfort of knowing that we are improving its quality here or there in proportion as we are giving one sense or another more or less exercise. The truth is that our senses are our best friends or our worst enemies in just such measure as we train or neglect them.

[1] Look up *Good Health* on the care of eye and ear.

CHAPTER XXXIX

HELP THROUGH HAPPINESS; OR, THE SYMPATHETIC GANGLIA

Before studying this chapter, test yourself in two ways. First, try with all your might to make your heart stop beating. Try to prevent the great arteries from expanding and contracting as the blood surges through them in pulses. See whether, by thinking and willing hard enough, you can prevent your sweat glands and oil glands from manufacturing salt water and oil. Will your stomach obey you when you command it to stop digesting your food?

Now turn the tables. Say to your heart as it pounds steadily along: "Beat faster. Beat faster. You must beat faster." Will it obey you? No; it goes neither faster nor slower by the fraction of a second. Your brain and your heart seem to be as independent of each other as if they belonged to different bodies and lived in different worlds.

Nevertheless, as we all know, life itself depends on the beating of the heart. We know that whenever it stops and fails to start again we shall die, but from year's end to year's end we think nothing about it. At night we lie down to sleep with no anxiety lest the steady

SPINAL CORD WITH SPINAL NERVES

On the left are a few sympathetic ganglia joined by their rope of nerve fibers

pulsing may cease. By day we run, dance, dive, swim, we play leapfrog and football, we walk on our hands and turn somersaults, knowing all the while that the heart is affected by every move we make; but through all that we do we seem also to know that somehow the body has an arrangement for controlling its most important life machinery whether we pay attention to it or not.

And so it has. Up and down on each side of the backbone is a chain of ganglia which holds more vital power, perhaps, than any other part of the nervous system. It seems to be nature's device for relieving the brain, — a device for keeping the vital machinery in running order whether the owner of the machinery gives heed or ignores it.

There we have it then! We have come upon the mystery of the so-called sympathetic nervous system, the mystery of the cells which take charge of internal, bodily affairs, — cells which do their faithful work whatever our commands to them may be. This work is in charge of what is called the sympathetic nervous system. So far

as location and arrangement are concerned it is not very difficult to understand the facts about this system, and the following outline will give them as simply as possible:

1. Forty-nine ganglia unite to form the main part of the sympathetic nervous system. These ganglia belong together as a complete set. Twenty-four lie on one side of the backbone, twenty-four on the other side, and one lies in front of the very last bone of the back.

2. Each of the forty-nine ganglia is connected with its neighbor above and its neighbor below by what might be called a rope of fibers.

3. This string of ganglia, held together by a peculiar rope, seems to hang like a loop, with the backbone as a pole in its center.

4. The nerve cells of the different ganglia send fibers off to definite parts of the body: to heart, stomach, liver, and elsewhere. At these different places the fibers are so closely woven together that they form a network called a plexus; small ganglia are interlaced with each plexus.

5. One very important plexus is near the heart, another near the stomach.

On the street the other day my four-year-old friend suddenly bent his head forward and thumped it into the stomach of an elderly man who came that way. The boy was surprised when the old man bent himself double and almost groaned aloud, for the child himself knew nothing

about the plexus near the stomach, neither did he know that wherever fibers are thickest, there it hurts most to be punched. The boy's brother, fourteen years old, understood the situation perfectly. He thought the man really needed to groan, "because," as he said, "you see it hurts awfully to be thumped in your stomach like that."

But all this has to do with the outside of the stomach. Now recall Dr. Cannon's experiments with cats. Think of the close connection which he discovered between the state of the mind and the work the stomach is willing to do, and do not forget that it is through nerves alone that the mind can ever affect the stomach in this way or that.

A friend of mine says that many a time when he was young he himself had the cat's experience. He was quick-tempered, nervous, and excitable, and he found that if he lost his temper while he was eating, or if he even became unpleasantly excited, he immediately felt as if all the food in his stomach had turned itself into a weight of lead that could not be dislodged.

Sometimes, however, his stomach did go so far in its rebellion as to force up everything he had swallowed. Various lessons of this sort at different times taught the boy one of the great lessons of his life, — that he must keep calm and serene at meal time.

From these and other observations and experiments scientists find four good reasons why happiness helps not the stomach alone, but all parts of the body too:

1. A happy state of mind affects the ganglia in such a way that they compel the small blood vessels to expand. This allows fresh blood to flow easily through them.

2. A happy state of mind affects the nerves that control the lungs. They inhale more air. This means that they get more oxygen, too; and this, in turn, means that the blood is better purified by the lungs.

3. A happy state of mind affects the ganglia that control the heart, making it beat faster; this forces fresh blood rapidly through the expanded blood vessels. And rapidly moving blood gives rich nourishment to nerve cell and muscle, making it possible for them to do good, energetic work.

4. A happy state of mind affects the ganglia of the stomach so promptly that its churning is better done; while, at the same time, more gastric juice pours in to help digestion along.

A cheerful schoolroom, lively games, pleasant friends, becoming clothes, travel by steam and by rail — anything that makes us happy without doing us harm is a help to the body through the sympathetic ganglia.

We now see why it is that we learn our lessons faster, recite them better, and are quicker-witted in every direction when we are joyful than when we are joyless and hopeless. It is simply because in the former state every

organ in the body is doing its best work, and because the brain gets the benefit of it all through an improved blood supply. The serious fact is that the human machine is so delicately balanced that when even the smallest part of it fails, the whole may hitch and halt. Wear out the fire box or the boiler of an engine, and no matter how perfect the rest of the machine may be, it will run no better than a worn-out affair that is rusted in every joint.

It matters not where the hitch in the human machine begins — whether with too much food, too little mastication, too little exercise, too much worry, excitement, anger, fear or torment of any mental sort; for, wherever the start may be, the feelings are sure to be pulled into the reckoning ere long, and after that the trouble is increased tenfold.

It is evident, then, that we have within our own reach methods for securing good service from our sympathetic ganglia:

1. By avoiding, as if it were a poison, each thought and emotion that saps the vigor of the ganglia: hatred, malice, envy, jealousy, anger, despair, discouragement, anxiety, worry, fear.

2. By helping the ganglia through love, joy, hope, courage, faith, trust, belief in others, belief in ourselves, good cheer.

3. By obeying all the health laws that we know anything about.

CHAPTER XL

PHAGOCYTE AND ALCOHOL, OR FRIEND AND FOE OF THE NERVE CELL[1]

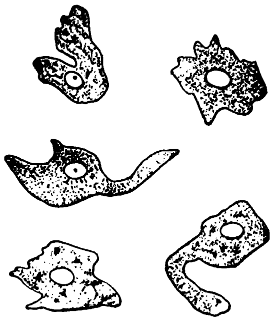
Scientists have known for a long time that the red blood corpuscle is the oxygen carrier of the body; but for years they came to no conclusion about the occupation of his busy companion, the white blood corpuscle, the phagocyte,[2] "the devourer," as his name means in Greek. The mystery vanished, however, when Professor Metchnikoff, of the Pasteur Institute, Paris, turned his attention to the subject.

He took a healthy frog, carefully pricked some cholera microbes under his skin, and with his microscope watched the fate which befell them. The whole affair was easy to follow, for white phagocytes now flocked to the spot from all sides; they crowded close; each seemed to choose its special victim, and, drawing closer yet, laid itself up beside the enemy, stretched itself into a new, curved shape, and little by little wrapped itself about the doomed microbe.

[1] These chapters are taken from *Control of Body and Mind*.

[2] All phagocytes are white blood corpuscles, but there are also white blood corpuscles that are not phagocytes.

The phagocyte is really nothing more than a tiny round speck of living, active, independent substance called protoplasm, but it captures its victims relentlessly. In vain the microbes tried to flee; their captors had surrounded them completely and held them firmly within their own bodies long enough to digest them. Instead of killing an enemy outright and throwing him aside, they rid themselves of him by swallowing him whole. Quickly hurrying to another, each phagocyte repeated the process, disposing of one microbe after another and growing larger with each captive.



SHAPES WHICH ONE PHAGOCYTE TOOK WITHIN A FEW SECONDS

When intruding microbes were small enough for it Professor Metchnikoff saw the phagocyte "swallow them in shoals as a whale swallows herring." Whereas, if they were too large for one to manage alone, several phagocytes would surround the same microbe and digest him in partnership.

In this connection it is interesting to know that a frog never dies of cholera. The reason is clear to us; frog phagocytes are so vigorous that they conquer cholera microbes before they have a chance to manufacture their deadly toxin and give cholera to the frogs. In the same direction Professor Metchnikoff

next discovered that pigeons cannot be made to take tuberculosis, for, here again, phagocytes seized the tubercle bacilli as fast as they entered the body and devoured them before any harm was done.

The work which the phagocyte does for the body is so valuable that we easily talk about this free-swimming, single cell as if it were a many-celled warrior with a mind of its own. In point of fact, however, and even though they do behave like friend and foe, there is no real enmity between the phagocyte and the microbe.

These small protectors of the body move from place to place in independent fashion. They spend most of their time in the blood; and in it they not only travel with the current but they also ignore that current entirely, and, like the salmon, swim up stream as well as down stream, as occasion may seem to require. At a moment's notice, also, they leave the blood and pass through any bodily tissue without the slightest difficulty.

Through Professor Metchnikoff's experiments and others since then, facts have been learned which help human beings. If our phagocytes are strong enough to destroy disease microbes for us, we shall be saved from certain serious diseases. If, on the contrary, our phagocytes are feeble, or if microbes enter our body in such swarms that there are not phagocytes enough to fight them successfully, the enemy will be victorious, the phagocyte will be defeated, and we shall be the victims

of any special epidemic that is traveling the rounds. Put two men into a town where cholera is working havoc; let one have more vigorous phagocytes than the other, and he will be the one more likely to escape with his life. Let measles or pink eye, whooping cough or influenza, break out in school, and those children with the most numerous and active phagocytes will suffer the

INFLUENZA MICROBES UNCONQUERED BY PHAGOCYTES

On the left, as they are found in the sputum of some colds; on the right, as they are raised in the laboratory

least. Let tubercle bacilli be thick in the dust we breathe, and those of us who own the best bodyguard in the line of well-developed phagocytes will be least likely to take the disease and suffer from tuberculosis afterwards.

The same law holds true even for less serious illness. When some one says, "I am so sensitive, I catch cold

at the least exposure," it is quite as if he said, "My phagocytes are wonderfully weak and inefficient, they are vanquished by all the microbes of influenza that enter my body." Another person says, "I never seem to take cold," and it is as if he said, "My phagocytes are such valiant warriors that they destroy every intruding microbe."

Yet the phagocyte is not merely an athletic policeman, a valiant soldier; he is also a scavenger and a street cleaner. With all his occupation he is never idle. Here and there through the body he hurries, always trying to remove waste matter and intruding microbes.

You cut your hand, or you run a sliver into your finger, and from every side phagocytes hasten to clear away the rubbish and to attack the microbes. If they can kill these mischief-makers as fast as they drift in, the wound will heal fast; if, instead, the phagocyte is too weak to slay the enemy, there will be a painful sore, slow to heal.

Hospitals are full of patients who prove this difference in their own bodies. One man has a wound that heals at once, and he goes home happy; another man stays in the hospital for weeks waiting for his wound to heal. The difference in recovery rests with the phagocytes of the two men. "Matter," or "pus," from a wound is the host of microbes and phagocytes that have been slain in the struggle. They are being washed away by fluids from the wound.

CHAPTER XLI

PHAGOCYTE AND ALCOHOL (CONTINUED)

The warfare within our bodies is a silent one. We hear no sign of any conflict; nevertheless, throughout our lives the strife goes on ceaselessly, and it makes all the difference between life and death to us whether or not our standing army of phagocytes is in good fighting trim.

In view of this fact our daily command to ourselves should be: *Protect the phagocytes from harm.* Every law of health is, indeed, so truly a law for their protection that he who follows health laws most strictly will at the same time be doing the most for his bodyguard. It is necessary, however, that we should know even more than this. Multitudes of cases prove the need.

In Glasgow, in 1848, a little more knowledge might have saved hundreds of lives. A great cholera epidemic swept through the city, and it attracted so much attention that Dr. Adams studied it for the sake of telling the people how to protect themselves. He kept a keen eye on the death rate of his cholera patients, and discovered that those who went without alcohol had a vastly better chance to recover than those who used it. Or, to put the facts more exactly, when those who used alcohol caught

the disease ninety-one out of every hundred died; whereas, when those who did not use alcohol had the cholera, only nineteen out of each hundred died.

Knowing what we do about the effect of alcohol on living tissue, and knowing also about the discoveries which Professor Metchnikoff made in connection with cholera microbes and phagocytes, we understand at once the condition of affairs in Glasgow. Those men and women who did not use alcohol owned phagocytes that were vigorous enough to conquer the attacking cholera microbes; those other men and women who used alcohol had weakened their phagocytes to such an extent that when invading enemies came they were not strong enough to slay them.

Dr. Delearde had two cases which illustrate precisely this point.

A man and a boy were bitten on the same day by the same mad dog. The boy, thirteen years old, was bitten on the head and face, which are the very worst places for such wounds. The man was bitten on the hand alone — a much less serious matter. Both victims were taken to Dr. Delearde, and he gave each his most careful treatment; but the man, who should have recovered, died of hydrophobia, and the boy, who might have been expected to die, recovered. The only difference in the two cases seemed to be that the man used alcohol and that the boy did not use it.

This led Dr. Delearde to look into the subject still farther. As usual, when experiments have to be made, he took two sets of rabbits; to one set he gave a little alcohol each day; the other set received no alcohol. He then vaccinated both sets to try to prevent them all from taking hydrophobia. After they were supposed to be proof against the disease, he put the poison of hydrophobia into their blood and was not surprised at results. Those rabbits that had had alcohol took the disease as easily as if they had not been protected against it; whereas the poison had no effect whatever on the rabbits that had not had alcohol. Evidently their phagocytes had served them well.

In looking back to the seventeenth chapter of *Good Health* we now understand one reason why Bum and Tipsy suffered so much more than Nig and Topsy when the epidemic of dog illness raged in Worcester. Alcohol had weakened their phagocytes to such an extent that disease microbes had the upper hand from the start.

Just here it is necessary to call attention to an important fact. When death comes from disease microbes it is not the microbe itself, but the poison which the microbe gives off while it multiplies, that does the mischief. Each disease microbe has its own special variety of poison — of toxin — and fevers of one sort or another simply show that a fierce fight is going on between microbes that are

producing poison and phagocytes that are devouring the poison producers.[1]

Over and over again, in many microbe diseases, death comes from the fact that one set of nerve cells or another has been poisoned or paralyzed by the toxin which the microbes have produced. It is here, then, that the connection between phagocyte and nerve cell steps in. By destroying the microbe which makes poison, the phagocyte protects the nerve cell. Very often, therefore, the battle between phagocyte and microbe is a battle in behalf of the safety of the nerve cell from the poison produced by the microbe.

This is particularly true in that dread disease, pneumonia; and sometimes a doctor helps science by following the record of the battle. From time to time he draws a drop of blood from the arm of his patient and examines it under the microscope for phagocytes. He knows that according as the number of these protectors increases or decreases, so also is there prospect of life or death for the sufferer himself. The normal count is from five thousand to seven thousand in each cubic millimeter, and it takes sixty-one cubic millimeters to make one drop of water.

When, by his examination of the blood, the doctor finds that the number of phagocytes is mounting steadily

[1] Pasteur's experiments which prove this are given in Chapter XXII of *Town and City*.

upward from ten to twenty thousand, from twenty to fifty and even to seventy thousand, he takes courage. He knows that "the body is rallying its forces to battle with invading hosts of microbes, and that, if the fight can be kept up long enough, the victory will be won."

Dr. Moorhead of Edinburgh, Scotland, was talking once about the treatment of pneumonia, and he said: "If I can get a patient who has had no alcohol I have very seldom any doubt as to the result of that attack of pneumonia, and I find that it is never necessary to give alcohol in those cases at all; in fact, patients do better without it." There are doctors who would not agree with Dr. Moorhead in this matter. Nevertheless it is true that, even as a medicine, all our best doctors, in our best hospitals and out of them, are in these later years giving vastly less alcohol to those who are ill than they gave in former times. They are understanding better and better the nature of the effect which it has on the life forces of the body.

Scientists claim that phagocytes are being manufactured constantly in certain lymph tissues, and that when a special need comes, when a wound is made in the flesh or when disease microbes multiply in the blood, then the tissues send out new regiments of soldiers by thousands and by millions. And it appears that, from the start, even the youngest among these soldiers are ready to risk their lives in immediate service.

Nevertheless, although a young and healthy phagocyte may be so vigorous as to be like a Samson among his microbe enemies, still, as we have seen already, there is a way to defeat and destroy him. Let one of these young phagocytes be launched into blood that has alcohol in it and what is the result? Does he gain courage for the fray? Does he scurry off to the battle ground with the greater strength?

Quite the contrary; his fate is now sealed, for that alcohol overcomes him as a subtle power more deadly than any microbe. It is a toxin which will dull a phagocyte or paralyze him utterly, according as there is more or less of it in the blood.

A trace of alcohol does not rob phagocytes of all power. They may still be strong enough to reach the scene of battle; they may even wrestle with a microbe on the way there; but instead of being strong enough to conquer, they are now weak enough to be conquered. When that condition exists disease microbes find themselves free to carry on their business of toxin manufacture without interruption.

From beer and hard cider all the way through to gin and brandy each drink harms the phagocyte with its alcohol, and the more alcohol the drink holds the more is the phagocyte damaged by it. The table which is given on the next page shows what per cent of alcohol is found in various drinks which are in common use.

Alcoholic Percentage of Common Drinks

Beer	3–5
Hard cider	4–5
Ale	7–8
Wines of different kinds	7–20
Champagnes	11–18
Brandy	30–55
Whisky	50

In view of this power of alcohol, we realize that when a man raises his glass cheerfully to his lips and drinks to the health of his king or his friend, he drinks in truth to the success of disease microbes in his own body, while at the same time he drinks to the death of his own most faithful bodyguard.

If the owner of a castle had drugged his watchmen on the towers, had bound his soldiers hand and foot, had killed his bodyguard, would he have the right to be surprised when he found his worst enemy within the gates? If that enemy robbed him, or beat him cruelly, or killed him through slow torture, would any one be to blame but the owner of the castle himself?

Protect your phagocytes from harm and they will protect you in time of need. Weaken them through the use of alcohol or any other poison, or through neglect of the laws of health, and you will be as a man who has drugged his watchmen on the towers, bound his soldiers hand and foot, and killed his bodyguard. He who has done all this is sure to suffer when the enemy comes.

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QUESTIONS

Chapter I

How do some cities get the records of a man? Which gives the better record, a photograph or the measurements of certain bones? After what age are bones set for life? Why does a nurse support the head and back of a young baby? How do Indian mothers secure flat heads for their children? Give two laws of bone growth. Describe the appearance of the boy who failed to get work. Describe the boy who secured work. In what ways does the body tell facts about us? How much responsibility have we for the bodies we live in?

Chapter II

Were you satisfied or dissatisfied with the examination of your own body? What points did you decide to change? Mention some objectionable positions to take when seated. Tell why each is objectionable. What difference is there between sitting with a twist in the back once in a while and taking the same position most of the time? What must be guarded against? Was it the older or the younger girls in the German school that had most trouble from lateral curvature of the spine? Why was this? Mention various positions that bring curves to the spine. What objection is there to these curves? Give four laws of prevention.

Chapter III

Mention the case of the strong, bent back, and tell how it was secured. Why do certain bicycle riders have bent backs? What law explains the

strong but bent back? How did a traveling man lower his shoulder? Describe the backs of two oarsmen, and tell why one is curved and the other straight even when they walk. Why does the hand of a piano player stay open even when he is not playing? Why do the fingers of an oarsman curl up even when he is not rowing? Mention such occupations as you think may change the shape of the body. Why is the body thus changed? Give the second great law about muscles stretching and contracting. How may a man who works in a bent position save himself from the evil effects of his work? Give such examples as you can call to mind.

Chapter IV

What did the doctor tell his audience they could do with their bodies? How did the student show what the muscles can do? How did his back and arms look before he forced the muscles into action? What was it that raised bunches here and there a moment later? How could muscles be pulled up so short and hard without the use of apparatus? What did the man pull against? What did the lecturer say about the way to develop muscles without apparatus? How often and for how long a time should the exercises be taken? How much change did the student say he had made in the size of his own arm within one month? What should be done to make a close examination of the structure of a muscle? What is a muscle fiber? What can you say about the size and the shape of different muscles? How is each formed? What is the sarcolemma? Where is the connective tissue? What lies within the connective tissue? Of what use are the fine threads of connective tissues that stretch away from the ends of muscle fibers? What do they help form? How do you explain the difference between tough and tender meat? Why is a spring chicken tender? How can you toughen your own muscle? Describe voluntary muscles. What is the work of involuntary muscles? How much do the muscles as a whole weigh? Can you mention the name of any muscle?

Chapter V

In what way do bones help muscles? How do muscles and tendons help bones? Describe the outside of a fresh bone. Describe the inside of a fresh bone. What is the advantage in having bones made in this way? What would a magnifying glass show? What two things can a chemist do to a bone? What good thing does a cook get from a bone? What are the two important substances which together form bone? Why should aged people be careful not to fall? Why do their bones break more easily than those of children? Why are young bones pliable? If, being young, you wish to change the shape of your chest, how will you do it? Describe the shape of different bones. How many are there in a human being? What is a vertebra? How many vertebræ are there? How are they held together? Explain how vertebræ may become wedge-shaped. What effect does hard work have on the bones?

Chapter VI

Describe the small foot of a Chinese lady. How was it secured? How useful was it? How many bones are there in the foot? How are they joined to each other? In order to have the foot in thoroughly good condition and as useful as possible, how much freedom should the muscles, bones, and tendons have? Which is most desirable, the flat or the arched foot? How can you decide which kind you have? If you have a tendency to flat feet, how can you help yourself? Why should feet be uncramped? What explains the ruined shape of many feet? In buying shoes, what points should be kept in mind? Why are tight garters objectionable?

Chapter VII

What fastens a muscle to a bone? Just how does a muscle help move a bone? To what bones are those tendons fastened which belong to the muscle which forms the calf of the leg? Where is the

contracting done, in muscle or tendon? What sometimes occurs to the bone when a tendon is badly strained? What connection is there between joints and the direction which bones shall take? Describe the joints which lie between the skull and the spine. Where do we find important ball-and-socket joints? What sort of joint is there at the knee? What is the difference between tendon and ligament? What is it that holds bones to each other? Name two kinds of joints. Where do you find examples of each?

Chapter VIII

In what ways do boys in some cities get their exercise? Of what advantage is this exercise? How does it happen that more attention is paid to the health of children to-day than ever before in the history of the world? What do the best athletic trainers of the country say about the use of alcohol and tobacco by their men? What part of the body does tobacco harm the most? What is the usual record, on the athletic field and in the class room, of those who habitually use cigarettes? Why has the American army often refused men who wished to join it as soldiers? Why should men with weak hearts keep out of the army? What did Mr. McBride say about the use of tobacco and alcohol by football players at Yale? What does Mr. Edwards say for the Princeton team? What does Mr. Stagg say? What does Mr. Gianinido say for the New York Athletic Club? Why did Nansen take no alcohol with him when he left the Fram?

Chapter IX

Tell how you may get the standard of your heartbeat when standing. How can you increase your heart beat? By what tests can you prove that your pulse shows what the rate of your heartbeat is? What difference do you find in your own case between your normal pulse and your pulse after a short, quick run? What other facts have you learned about your pulse? Is it by the exercise of large or small muscles that you

increase your heartbeat the most? Why does a doctor feel the pulse of his patient? What mistake do frail women sometimes make about the use of the heart? What is the opposite mistake which a bicycle rider sometimes makes? What is the heart and where does it lie? How large is the heart and when does it work? How did the heart of the tennis player show that it was overtaxed? How should the man have begun his playing in the spring? Mention some way by which muscles and heart and breathing apparatus may all be trained at the same time. Describe the work of the doctor as he trained the man who fainted easily. What objection is there to an overstretched heart muscle? Think of some advantages that come from having a heart well trained for its work. What difference is there in the size of the heart of wild and caged animals? How may you train your own heart?

Chapter X

To what two men do we owe the largest debt for our knowledge about the heart and the circulation of the blood? When did Galen live? Who was William Harvey? Where was he lecturing in 1616? What did he notice about the flow of blood from different wounds? What was Harvey's first great discovery? Give some facts that led him to this discovery. How many quarts of blood are there in the body? How much blood does the heart send out each time it contracts? How often does it contract each minute? Where are the pockets in the veins? Which are deeper in the body, arteries or veins? Describe the experiment with the bandage above the elbow. What does it prove? What was Harvey's second discovery? What can you say about the two halves of the heart? What connection does each side have with pure and impure blood?

Chapter XI

Describe the experiment which shows how long it takes blood to make the circuit of the body. How long does this take for a man? for a

child of fourteen? Describe the circuit of the blood from the veins back to the veins. How does the blood get from the arteries to the veins for its return journey to the heart? What does the microscope show in the tail of a tadpole? When you cut yourself and blood flows what have you actually done? What does capillary mean? What can you say about the amount of blood which the blood vessels might hold? In what way is warm salt water sometimes useful in the blood vessels? What connection is there between exercise and the amount of blood which is sent to different parts of the body? Give this law of exercise.

CHAPTER XII

What is the object in using a rough towel after the morning bath? Describe the way to get a drop of blood for examination. Why do you put the needle into the flame before using it? In getting the blood what do you do to the capillaries? What is the color of the blood? How do you know that blood hardens soon after it leaves the body? What happens to the bit of jelly after it has been left undisturbed for about half an hour? What can you say about the value of blood while a wound heals? What does a drop of blood show when it is examined through a microscope? What three things are mixed together to form blood? Tell all you can about red corpuscles. Describe white corpuscles. What is the liquid part of blood called? Describe it. What does a chemist have to say about blood?

CHAPTER XIII

What can you say about the importance of getting the blood into close contact with muscle and gland? Describe an experiment with tumblers which proves that certain substances can pass through a moist animal membrane. What have men discovered about the power of certain gases to pass through animal membrane? How will you apply these experiments to the work done by the liquids and the gases within the body? What is lymph like and where is it found? Which gas passes

from the tissues of the body into the lymph? How does this gas reach the red corpuscles? How does oxygen from the red corpuscles get to the tissues? Which two gases change places in the red corpuscles? Tell what you can about blood in the arteries. Describe blood in the veins. Describe lymph. Describe the origin of lymphatic tubes. What is the difference between the system of blood vessels and the system of lymphatic tubes? What does lymph look like? What does plasma receive from lymph? What does lymph receive from plasma? Of what use are pocket valves in the lining of the lymph tubes? How does vigorous exercise help the body through the lymph? Why is it an advantage to the tissues to be surrounded by fresh lymph?

CHAPTER XIV

When the nose or any other part of the body is red, what do we understand about the capillaries just there? What objection is there to having blood move slowly through the capillaries? Mention two advantages that are connected with fast-moving blood. Why should the walls of the blood vessels be kept healthy, vigorous, and elastic? What did doctors formerly think about the connection between alcohol and circulation? After a man takes alcohol does his heart beat faster or slower? What is the sphygmograph for? What does the sphygmograph show about the power of the heart before and after alcohol has been used? It beats faster, to be sure, but what about the force which it puts into each stroke? Does this prove that the heart receives strength or is robbed of strength by the alcohol? What is the natural condition of the blood tubes? Are they elastic or nonelastic? What effect does alcohol have on them? Why is it harmful to have slightly paralyzed blood tubes? What effect has alcohol on the heart? Describe what the result is when both blood tubes and heart are thus weakened. What finally happens to the walls of the tubes? What effect does this have on the exchanges between plasma and lymph? Why does the body suffer when the

exchanges are made slowly? Describe the condition of the heart after it has been weakened by alcohol. What objection is there to fat among the fibers of the heart? Why do surgeons dread to operate on a man who uses alcohol?

Chapter XV

If you were ever thoroughly out of breath describe the sensations you had. While you ran what was happening to the substance of the living tissues of the body? What gas was produced by the tissues as they worked? What gas did they need in order to carry on their work? Through what stream did the tissues get rid of their carbon dioxid and receive their oxygen? Why did the blood stream need to flow fast? Give five steps that are connected with breathlessness. What did people formerly think was the cause of breathlessness? What do people think about it now? What can be done to strengthen the heart? When does carbon dioxid form fastest? When do we use the most oxygen? When does a man give off the least carbon dioxid and call for the least oxygen? Why is the heart overtaxed when we run hard? What does a trained athlete learn about keeping the balance of the gases in his blood? When is he willing to be breathless? During exercise, which muscles call for the most oxygen in the least time? Which two organs of the body need to be trained in their relation to each other?

Chapter XVI

Mention some tests which show that the size of the lungs can be increased. How many lungs have we? Where are they? What is an air sac? When is blood called impure? When is blood pure? What is the condition of the blood when it enters the lungs? when it leaves the lungs? In what way are the lungs a storehouse? What exchange goes on in the air sacs? Where is the oxygen taken by the red corpuscles? Is it for the benefit of the lungs or of the tissues that we breathe? How long does it take blood to make the circuit of the body? Describe the way oxygen

and carbon dioxid change places in the lungs. Why are large lungs an advantage to the body? How may their size be increased? What are the best kinds of exercise for the lungs? What danger comes from inactive air sacs? Where does tuberculosis most often begin? Why should breathing be done through the nose and not through the mouth? Why should air be well cleaned before it enters the air sacs?

CHAPTER XVII

Who was Dr. Koch? What was his great discovery? What is the annual death rate from tuberculosis in the United States? in the world? Give as many facts as you can about the tubercle bacillus. In what places do we find the most consumption? Describe "Lung Block." How does one case of consumption lead to others? Where do the microbes stay? How do they reach the air? What objection is there to dry sweeping and to a feather duster? How do tubercle bacilli reach the lungs? Give their history after that. Why is sputum dangerous? How may parents give consumption to children? So far as tubercle bacilli are concerned what special advantage is there in having vigorous lungs?

CHAPTER XVIII

Describe the fight against tuberculosis in Maryland. Mention two ways by means of which tuberculosis may be banished. Give the triple motto of the campaign. Mention two ways in which tubercle bacilli get into the air we breathe. Why do cities have laws against spitting? Give three rules of prevention. In what way is tuberculosis like a fire in the lumberyard? What four things are needed to cure consumption? What are the five tuberculosis "D's"? What is the golden rule of the antituberculosis leagues? What can you say about using medicine for consumption? How can a house be kept supplied with fresh air? What advantage has night air? In sleeping in cold, fresh air, what must be done about keeping warm? How do city hospitals manage to give their

patients enough fresh air? Tell about Dr. Fisher and others who have slept out of doors. Why are open-air classes being started for children?

Chapter XIX

Give the chemist's reason for objecting to alcoholic drinks. Who was Dr. Warren? How many samples of adulterated liquors did he find among the six hundred which he examined? Mention some of the poisons used in adulterating the liquors. What did the manager of the St. Louis Wholesale Liquor Association say about adulterations? Give two reasons why alcoholic drinks are adulterated. What must the drugs do for the drink? Which is the more dangerous, pure alcoholic drinks or adulterated drinks? Why? Give the case of the two men who drank whisky. What did Dr. Cox discover about the whisky? What did Mr. Redding say about port wine? How is fruit juice keep sweet for years? If it is unboiled what occurs? If it begins to ferment before it is bottled what is produced in it? Into what two things do ferment microbes change sugar? What two substances are found in all wine, cider, beer, and similar drinks? What connection is there between sugar, ferment, and alcohol? How is beer made? Why does a bottle of champagne pop when opened. What is the great objection to patent medicines? In which medicines is there a large per cent of alcohol? What does the United States law about patent medicines demand? How can we tell whether a bottle contains poisons or not?

Chapter XX

What men were used as a sort of laboratory for food experiments? Give the age of the youngest and the oldest soldiers? In what town were the tests made? What special treatment did the men receive? Did they eat more or less than other men? What was the result? What did the tests prove about the need a man has for meat? Who should eat most and who should eat least? Mention two things that food does

for the body. Mention the five food substances. Whence do plants get their nourishment? Whence do animals get theirs? Which kind of food contains the most proteid? What two kinds of food does the word "carbohydrate" include? Is carbohydrate most abundant in the food we get from plants or in that which we get from animals? Which food substance does the body use in building up tissue? Which does it use as fuel for energy? Which for warmth? When too much carbohydrate is eaten what becomes of the surplus? When too much proteid is eaten what becomes of the surplus? When does a person need the most proteid and the most carbohydrate? If we do not eat meat what articles should we use instead, to supply ourselves with proteid? Plan some meals where the proteid is supplied by something else than meat. (You will need to study the table for this.) Why are creamed potatoes more nourishing than potatoes boiled in water? Why is macaroni and cheese a most nourishing dish? Why would it never do to take our nourishment in condensed tablets?

CHAPTER XXI

Where did Dr. Cannon conduct his experiments on cats? Why were cats chosen? Why was bismuth mixed with the cats' food? What did Dr. Cannon wish to learn about the stomach? Why did he use the X-rays? Describe the waves of motion. Describe the changing shape of the stomach. How soon after eating did the food begin to leave the stomach? What is the name of the muscle that guards the outlet? Describe the uneven action of the pylorus after the cat swallowed the tablet of bismuth and starch paste. What did this experiment prove? Why is it a disadvantage to have food detained too long in the stomach? What discovery did Dr. Cannon make in connection with the cat that lost its temper? What emotions have the power to stop all action of the stomach? What effect does a happy mind have on the work which the stomach does?

Chapter XXII

What special disease became a scourge in Pittsburg? How many died of typhoid fever in 1907? How did other people suffer from the disease even when they did not die? How long did the scourge last? What caused it? How could it have been prevented? Why was it not prevented? Tell what you can about the typhoid microbe itself. How does it get into the body? What do towns on the banks of the Allegheny and Monongahela rivers do with their sewage? Where does their drinking water come from? Why was Pittsburg water worst of all? What one thing is it that makes water unfit to drink? Describe the change that came in the Pittsburg death rate in 1908. What explained the change? Describe the Pittsburg sand filters. What do they do to water? Where does your own drinking water come from? Why is river water generally unsafe to drink? Why is water from a lake unsafe? When is well water unsafe? How can sewage get into a well? What do cities do for water? Tell about London water. Why is rain water safe to drink? Describe the typhoid epidemic in Springfield. Describe the difference between clean milk and unclean milk. How do microbes get into milk? Why should milk be clean, fresh, and cold? In what sort of milk do microbes multiply fastest? How can unclean and unsafe milk be made safe to use? Mention two ways in which harm may come through microbes in the milk.

Chapter XXIII

What is food in the stomach called when it is soft enough to pass through the pylorus? How long is the small intestine? How thin is chyme when it passes through the pylorus? What makes it grow thinner yet in the food tube? What is chyme called after it enters the food tube? Describe the action of the food tube as it was studied by means of the X-ray. How rapidly did the peristaltic action take place? How fast did the chyle move through the tube? Would rapid movement of

the chyle be an advantage or a disadvantage to the body? Where are the villi? What are they for? Why is chyle squeezed up against them so often? If food is not absorbed by the villi what becomes of it? From the time food is cooked and eaten until its journey is ended what is all the preparation for? How many villi are there? What is each one like? What do they do? What is the great object of peristaltic action? What happens when the food is not thoroughly prepared for the villi? Where, then, does food meet its final test? What happens to food if it is kept too long either in the pantry or in the food tube? Give some reasons why a person may be only half nourished although he swallows a good deal of food. Describe the progress of a mouthful of food from the time it is put into the mouth until it reaches the villi.

Chapter XXIV

Tell what you can about the effect of tempting a dog with meat? How many sets of salivary glands are there? What two things make saliva flow? Have you tested yourself in both these directions? Why does a sensible man with a weak stomach eat dry toast rather than delicate custard? How does saliva affect starch? What does it do to certain kinds of sugar that are hard to digest? Give two reasons why we chew food thoroughly. (First, to soften it; second, to mix it with saliva, which will change it and prepare it for its next course of treatment.) Why should babies, and older persons also, take their milk in sips and not in a pouring stream? What can gastric juice do to raw meat? Which needs more chewing, raw or cooked meat? Describe the gastric glands. Describe the tests with dogs which proved certain points about the flow of gastric juice. What should always be done after tempting a dog with food? Under what circumstances does gastric juice flow fastest and longest? What can you say about the advantages of hunger? Give two reasons for cooking food. What does cooking do to starch cells? Why should oatmeal and other cereals be thoroughly cooked?

Chapter XXV

What is the name of the largest gland of the body? Where does it lie? How much does it weigh? What does the liver do with the liquid food which it receives from the villi? What is glycogen for? What does the liver do with venous blood? What is bile good for? Mention the three occupations of the liver. What does a doctor sometimes advise a man to do when he has liver trouble? Why is a piece of raw liver so bloody? Why is alcohol especially harmful to the liver? How large does a liver sometimes become through the use of alcohol? What objection is there to fat in the liver? Where are the kidneys? What do they look like? What do they do? If they are out of order and cannot clear the blood of its proteid waste what becomes of this waste? What diseases follow? What do insurance companies think of a man whose kidneys are out of order? What do scientists say about the effect of alcohol on the kidneys? Why is beer especially harmful? (Because, being a weak drink, it is usually taken in large quantities.)

Chapter XXVI

Describe the woman who laces. What harm is she doing to her liver? Why will her complexion probably suffer? What does lacing do to the stomach? How does lacing affect the food tube? What is the diaphragm? Describe its location. What work does it do? What organs lie below it? What is above it? What tubes pass through the diaphragm? What work is done by the organs above the diaphragm? What is done by the organs below the diaphragm? In what way is the diaphragm connected with breathing? When you contract your diaphragm is air drawn in or expelled from the lungs? When the diaphragm contracts what does it do to the organs below it? What organs are helped by the exercise which this regular action of the diaphragm gives them? How does lacing interfere with the work of the diaphragm? What effect does lacing have on the lungs and on the heart? For best health how loose

should the clothes be? Why should weights be kept from dragging down on the abdominal wall?

CHAPTER XXVII

Where and what is Okushiri? What was the occupation of the inhabitants? What was their condition in 1884? How did they solace themselves? What kind of man was the governor and what did he advise his people to do? Tell what you can about the formal statement which some of them drew up. What was the object of this statement? Who were asked to sign it? When was this done? Mention some of the things to which they pledged themselves. How were the fines to be spent? How long was the contract to be in force? How many signed the contract? At the end of the five years what was the condition of the Okushiri islanders? How were they then regarded by neighboring people? What did they then decide to do for the next five years? If you care to do so find out the price of one glass of beer and also the price of various articles of food, and decide for yourself how much a man can buy during one year with what he might have spent for three glasses of beer a day during that year.

CHAPTER XXVIII

What report was posted on the important buildings of Paris in 1902? By whom was the report made? Mention some of the statements which it contained. Why are different nations protesting against alcohol? How do anti-alcohol leagues do their work? Tell something of what is being done in Germany. Who are the most prominent men in this German movement? What can you say about the royal family of Sweden? What has Japan done in the line of prohibition? In 1908, in the United States, how many people were living under anti-alcohol laws which they themselves had made? What danger threatened Indian Territory in 1905? How long had the Five Civilized Tribes been

protected from alcohol by the United States government? What did Indian Territory dread if it should become a state? Who were interested in keeping alcohol out? Who were anxious to let alcohol into the new state? Tell what you can about the activity of each side. How long did the agitation last? After Indian Territory was joined to Oklahoma what was the new state called? Give in your own words a part of the temperance law which now protects Oklahoma from alcohol.

CHAPTER XXIX

What were scientists trying to learn about the heat of the body in 1775? Describe the way they tested their bodies in heated rooms. How hot was the air? What happened to beafsteak, eggs, water, and watch chains that were in the same room? How did the men feel? What saved them from being cooked? When were the sweat glands most active? How many sweat glands is a human being supposed to have? Describe the epidermis. Describe the dermis and tell what is in it. Describe perspiration. How does it keep the skin cool? What things are mixed with perspiration on an unwashed skin? From what part does new skin grow to cover a wound? When a wound is too large to be covered by skin that grows from the edges what is done to supply a man with new skin? When is perspiration called "insensible"? What is sensible perspiration? When a man is heated what happens to the capillaries? When a heated man sits in a draft what do the capillaries do? Where is the blood sent from these capillaries? What is generally the first symptom of a cold? Describe the behavior of white corpuscles at such times. When white corpuscles are inactive what about the microbes? Why is a man who has a cold more liable to take other diseases? If you feel a cold coming on what should you do to check it? In what ways may we take cold by chilling the blood? Think of ways by means of which the body may be so helped every day as to be better able to resist disease.

Chapter XXX

What can you say about the heat of the body in different countries? What is the normal temperature of a human being? Which animals are warm-blooded? What is the difference between warm-blooded and cold-blooded creatures? Why does a room grow warm when several people are present? Why do we wear more clothes at one time than at another? How does exercise help keep the body warm? What connection is there between food and the power of the body to heat itself by exercise? When much exercise is taken what stored-up fuel is drawn upon? What may a fat man do to change his appearance? How can you explain the fact that hard exercise has little effect on the inside temperature of the body? Since the body can cool itself when it is too warm, what is the danger? Give three rules for preventing the escape of heat when the body needs it. Are we warmed by keeping the cold out or by keeping the heat of the body in? Why do we choose flannel for winter and cotton for summer wear? Give four rules that help the body to adjust itself to heat and cold. What is the great work of hygiene?

Chapter XXXI

Give what you can of the Kansas law about the common drinking cup. Describe Professor Davidson's experiments with pieces of glass that had touched the lips. Describe the appearance of the cup used by the high school. What experiments were made? Why do we refuse to put into our mouths things that have been used by others? Describe the eye epidemic in Germany. How may eye trouble be passed from one to another in a schoolhouse? Give a sure way by means of which one may avoid taking a contagious eye disease. Why should pencils never be moistened by the lips? Why do we object to flies? In what way may flies carry disease to a house? Where do flies multiply? Give reasons why garbage, refuse, and decaying waste should never be allowed to

accumulate. What connection is there between the barnyard and flies? In the Spanish-American war which killed the largest number of soldiers, microbes or bullets? What did the doctors say about it? Describe Dr. Lord's experiment with flies. What scourge came to Philadelphia in 1795? What has science proved about the connection between yellow fever and mosquitoes? What about malaria and the mosquito? What does a careful housewife do? What does a careful city do? Why are we all so anxious to be clean and to live in clean surroundings? How are mosquitoes exterminated?

Chapter XXXII

How did a certain New York boy start an epidemic? What harm was there in the skin he distributed? When we say "There is an epidemic" what do we mean? What did smallpox do in Ponape? Who was Dr. Jenner? What was his great discovery? Why are we now so safe from smallpox? What did New York City do to save itself in 1901? Why do epidemics spread fastest in crowded places? When a person has diphtheria, what must be done at once? Is antitoxin given to save a child after he has diphtheria or to protect him from it when he has been exposed to it? What difference has antitoxin made in the death rate from diphtheria? When a person has been bitten by a mad dog, what should be done immediately? Why is delay dangerous? Review the points about prevention that have been given in the last two chapters. What two things does the health of the body demand of us?

Chapter XXXIII

Who was Professor Kraepelin? What did he wish to do? What do some people believe about the helpful effect of wine and beer? With whom did Professor Kraepelin experiment? Describe the tests in adding columns of figures. What did these tests prove about the use of alcohol when one wishes to do quick, accurate work? With whom did

Dr. Aschaffenburg carry on his experiments? Describe the alcohol habits of the four men. What did Dr. Aschaffenburg wish to find out? How much alcohol did the men take on the days when it was given? Describe the experiment. What did the men themselves think about their own work when they had used alcohol? What did these experiments prove? What did Sweden wish to discover about wine and beer? What kind of men were selected for the experiment? Describe the experiments. How much alcohol was used? What did staff surgeon Mernetsch say about these experiments?

Chapter XXXIV

Mention some ways in which sensations help us. Before the microscope was invented what did scientists think about nerves? What does the microscope show? What do nerve fibers look like? Where are they? In what ways do they help us? Describe the different work of the two groups. Mention different sets of fibers that have been at work when a baby sees a flame and puts his finger into it. What does the brain do when the stimuli reach it? Which are the longest fibers? If we could separate the nerves from the body and stiffen them up, what would we be able to learn about the shape and size of a man? If we should cut the figure open, where would we find great clusters of nerves?

Chapter XXXV

Describe the actions of the dog that had lost the use of the cerebrum. What happens to a man when he loses his entire cerebrum? What mental activities are connected with the cerebrum? Where is the cerebrum located? When the brain has been preserved in alcohol what does it look like? Is it one solid mass or can it be separated somewhat? where are the parts held together? Give the names of two important divisions of the brain. Which is the larger? What does it look like? Where is the cerebellum? What can you say about the deep creases in both the cerebrum and the cerebellum? What good do the creases do? What is

the color of the outside of the brain? How thick is the gray layer? In what way is it useful? What do scientists say about injury to special parts of the gray layer? What do they say about the close connection between definite parts of the brain and definite parts of the body? What is the gray layer called? How important is it? How is it protected? What separates the brain from the skull?

CHAPTER XXXVI

In looking at the tangle of fibers under the skin what might we imagine? If we could untangle the fibers and follow them from start to finish, what should we find? What is the difference between large nerves and small nerves? Where are the largest nerves found? Describe the backbone and the nerves that pass through it. How many fibers may there be in each nerve? How do fibers pass from one bundle to another? What danger is there that a fiber will lose its way? What points do the fibers connect? When do fibers become useless? Describe what would have happened to the burning baby if one set of fibers or another set had been cut across. When is an impulse sure to be truthful? Describe the case of the soldier who had lost a leg. Let seven pupils give, one after the other, seven facts about the cells and the fibers of the nervous system. In what two ways does a cluster of cell bodies resemble a telegraph station? What is the vital part of a nerve cell? How often do fibers that carry messages in opposite directions make mistakes? How does it happen that fibers never exchange messages? Of what is the gray layer of the brain composed? What makes up the white part of the brain?

CHAPTER XXXVII

What did Flourens discover about a pigeon with a useless cerebellum? What did these facts show about the work of the cerebellum? In what way does the cerebellum relieve the cerebrum? Describe learning to walk. Mention other daily acts that are done at first with conscious

thought and end by being done unconsciously. What was the college freshman trying to do? If we are bent on teaching ourselves lessons, at what point have we a right to feel encouraged? Describe some case in which nerve cells are trained in spite of our real desire, — the expression of the face for example. How is it that feeling can express itself in the face through the muscles? Why is it that old faces betray their owners more promptly than young faces? Let four students give the four great laws of the nerve cells.

Chapter XXXVIII

When a person studies birds, what special senses does he train? Mention other ways in which a man may train his eyes and his ears. How do the native Australians train their eyesight? What connection is there between constant practice and training the senses? What about close attention? How many parts are there to the machinery which does the work for each separate sense? What are the parts? How much does the outside ear apparatus know about what is happening to it? When stimulus from the eye apparatus reaches the brain, what do we say? What is the receiving point for every message from each sense? What are men able to tell about the senses by examining the brain after death? Which sense is most developed in a bird? Which in a dog? Tell as much as you can about Laura Bridgman, — about her lack of different senses and about the condition of her brain after death. What three lessons do we learn from the study of the senses?

Chapter XXXIX

What control have you over the beating of your heart? When is the beating of the heart important? What part of the nerve machinery has charge of internal bodily affairs? Let five students give five important facts about the sympathetic nervous system. How can the mind influence the stomach? What was Dr. Cannon's discovery about the state of a

cat's feelings and the work of the cat's stomach? What similar discovery did a man make about his own state of mind and his digestion? Let four students mention four reasons why happiness helps all parts of the body. Why is it that we do better work with both the mind and the body when we are joyful than when we are joyless? Give three ways by which we may secure good service from our ganglia.

Chapter XL

What is the phagocyte? What does its name mean? Describe the experiment of cholera microbes, the frog, and the phagocytes. How do phagocytes capture and destroy microbes? Why does a frog never die of cholera? Why do pigeons never have tuberculosis? Describe the action of phagocytes in the body. If intruding disease microbes are more numerous or more vigorous than our phagocytes, what happens to us? If a man or child yields quickly to a disease, what does this prove about his phagocytes? If he is able to resist disease, what is it that has saved him? What does the phagocyte do in case we are cut or wounded? What is pus? What difference may there be in the healing of the wounds of two men in a hospital?

Chapter XLI

What should be our daily command about phagocytes? What connection is there between health laws and the vigor of the phagocyte? Speak of what happened in Glasgow in 1848. How do you explain the connection between the death rate and the drinking of alcohol? Tell about the boy and the man bitten by the mad dog. What experiments did Dr. Delearde make on the rabbits? How did he explain results? Why did Bum and Tipsy suffer more from the epidemic than Nig and Topsy? Which does the most harm in the body, disease microbes themselves or the toxin they produce? In what way do phagocytes protect nerve cells? In a case of pneumonia, why does a doctor take courage

when phagocytes increase their numbers? Where does he look for the phagocytes? What occurs when a phagocyte finds itself in blood that holds a trace of alcohol? When phagocytes are overcome by alcohol, what is the outlook for disease microbes in that body? When a man drinks to the health of his friend, to whose success and to whose death is he really drinking? Why should we protect the phagocytes from harm?

GLOSSARY

KEY TO PRONUNCIATION

a as in fāte, senāte, făt, ärm, ạll, ȧsk, whạt, câre.
e " mēte, ēvent, mĕt, hẽr, thêre, obey.
ee " fēēt.
i " īce, ĭdea, ĭt, sĩr, machïne.
o " ōld, ōbey, nŏt, möve, wọlf, sȯn, hôrse, wõrk.
oo " fōōd, fŏŏt.
u " ūse, ūnite, ŭp, fûr, rụle, pụll.
y " flȳ, mȳself, babỹ, mỹrrh.
au " author.

aw " saw.		ew	as in new.	oi	as in boil.
oy " boy.		ou	" out.	ow	" cow.
c (unmarked) as in call;		ç	" mice.	ci (= sh)	" gracious.
ch (unmarked) " child;		çh	" chaise;	ch (= k)	" school.
g (unmarked) " go;		ġ (= j)	" cage.		
ng as in ring.		n̲ (= ng)	" ink.	ph (= f)	as in phantom.
ṣ (= z) " is.		si (= sh)	" tension;	ṣi (= zh)	" vision.
th (unmarked) as in thin;		th	" then.	ti (= sh)	" motion.
x (unmarked) " vex;		x̣ (= gz)	" exact.		

Obscure sounds: ạ, ẹ, ị, etc. Silent letters are italicized.

ȧ dŭl'tĕr āt*e*, to corrupt by mixing with inferior materials.

ăl ĭ mĕn'tȧ rỹ, pertaining to food.

ăl ĭ mĕn'tȧ rỹ canal, the food canal.

ăm'bụsh, a lying in wait.

ăn ŏph'ẹ lēṣ, mosquitoes that carry malaria.

ăn tĭ tŏx'ĭn, a substance which neutralizes the action of a toxin or poison.

ā ôr'tȧ, the great artery from the heart.

är'chĭ tĕct, one who plans buildings.

är'tẽr ỹ, one of the vessels or tubes which carry the blood from the heart.

ăth'lēt*e*, one trained to exercises of agility and strength.

ăt'rŏ phỹ, wasting away from lack of nourishment.

bȧ çĭl′*l*ŭs, a microbe which is the cause of various diseases.

bĕv′ẽr ȧġ*e*, drink of any kind.

bī′çĕps, a muscle having two heads; the term is applied to a muscle in the arm.

bis̱′mŭth subnitrate, a chemical.

căp′ĭ*l* lȧ rȳ, one of the fine vessels or tubes connecting the arteries and veins.

cär′bŏn dī ŏx′ĭd, carbonic acid; a gas.

cär′tĭ lȧġ*e*, an elastic tissue; gristle.

çĕr ē bĕl′*l*ŭm, a division of the brain situated at the back of the head below the cerebrum.

çĕr′ē brŭm, the upper and larger division of the brain.

ehȳl*e*, the contents of the small intestine.

ehȳm*e*, food in the form in which it passes out of the stomach.

çĩr cū lā′tiȯn, motion in a circle or circuit.

çĩr′cū lȧ tō rȳ, pertaining to circulation, as of the blood.

cō′cȧ ĭn*e*, a drug which produces local insensibility.

cŏn′cāv*e*, curved in.

cŏn trăc′tiȯn, a shrinking; shortening.

côr′pŭs *c*l*e*, a minute particle; blood corpuscles, — the blood disks or cells.

côr′tĕx, the layer of gray matter covering the surface of the brain.

cr̤ud*e*, raw, not fitted for use by any artificial process.

cū′lĕx, the common, harmless mosquito.

cûr′vȧ tūr*e*, a bend; a curve.

dẽr′mĭs, the second layer or true skin.

dī′ȧ phră*g*m, a muscle separating the chest from the abdomen.

ĕp ĭ dẽr′mĭs, the outer layer of skin.

ē văp′ō rā′tiȯn, conversion of a fluid into vapor.

ĕx pĕc′tō rāt*e*, to spit.

găn̲′glĭ ŏn (plural ganglia), a collection of nerve cells.

ġĕl′ȧ tĭn, a substance made by boiling bones and other animal tissues. It is used in glue and as a jelly for food.

glŏb′ūl*e*, a little globe.

glȳ′cō ġĕn, a substance found in many animal tissues and especially abundant in the liver.

ġȳm′năst, one skilled in athletic exercises.

hī′bẽr nāt*e*, to pass the winter in a torpid state, as some animals do,

hȳ drŏ phō'bĭ ȧ, a disease caused by the bite of a mad dog.

ĭn grē'dĭ ent, one of the elements of a combination, as a drink or medicine.

ĭn ŏc'ū lāte, to introduce a disease germ into the tissues for protection from a more severe form of disease.

lăt'ẽr al, sidewise.

lēague, persons united for some particular purpose.

lĭg'ȧ ment, the tissue that connects bones.

lȳmph, a colorless fluid in animal bodies.

lȳm phăt'ĭc, a vessel which conveys lymph.

mĕm'brāne, a thin, soft tissue in the form of a sheet or layer covering parts of the body.

mī'crōbe, a creature so small that it can be seen only through a microscope.

mī'crŏ scōpe, an instrument for examining objects too small for the naked eye.

mŭs'cle, a tissue in animal bodies whose contraction causes motion.

mŭs'cū lar, having well-developed muscles; strong.

nôr'mal, regular; natural.

nū trĭ'tiȯn, that which nourishes or repairs the waste in tissues.

ō'pĭ ŭm, the dried juice of the poppy; a drug.

ôr găn'ĭc, pertaining to objects that have organs; hence pertaining to the animal and vegetable worlds.

ŏx'ȳ ġĕn, the element of the air that supports life.

păr'ȧ lȳze, to render helpless.

păt'ent mĕd'ĭ çĭne, a prepared medicine the composition of which is patented.

pĕr ĭ stăl'tĭc, contracting in successive circles.

pĭg'ment, coloring matter.

plăṣ'mȧ, the liquid part of the blood.

plē bē'ian (y), pertaining to the common people.

plĕx'ŭs, a network.

Pō'nä pe, one of the Caroline Islands.

prō'tē ĭd, a substance from which living tissue is formed.

pŭlse, the beating of the heart as felt in the arteries.

pȳ lō'rŭs, the opening through which the contents of the stomach pass into the intestine.

rĕg ĭ mĕn'tals, military clothing.

rhy̆th'mĭc, sounds occurring regularly, as accents in poetry or music.

rĭck'ĕts, a disease of children, in which they are weak in the joints.

rō'tāte, to revolve; to move round a center.

sä'ke, a Japanese fermented liquor made from rice.

săl ĭ çy̆l'ĭc, the name of an acid.

săl'ĭ vâ ry̆, pertaining to saliva.

sär cō lĕm'mȧ, the covering of separate muscle fibers.

sphy̆g'mō grȧph, an instrument used in determining the strength of the heartbeat.

spū'tŭm, that which is spit or raised from the lungs.

stĕg ō my̆'ĭ ȧ, a mosquito that carries yellow fever.

stĭm'ū lant, that which excites; a medicinal agent for increasing vital activity.

sy̆m mĕt'rĭc al, well proportioned in its parts.

sy̆r'ĭnġe, an instrument like a pump, drawing in and ejecting liquids.

tăd'pōle, the young of a frog.

tĕn'dȯn, a bundle of fibers which joins a muscle to a bone.

tĕnse'ly̆, tightly; rigidly.

tŏx'ĭn, poison produced in the system.

trō'phy̆, a memorial of victory.

tū bẽr cle, a small mass of diseased matter.

tū bẽr cū lō'sĭs, a disease caused by the tubercle bacillus; tuberculosis of the lungs is called consumption.

vein, a vessel which receives blood from the capillaries and returns it to the heart.

vẽr'tē brȧ, one of the joints of the spine.

vĭl'lŭs (plural villi), a minute elevation on the lining of the small intestine.

INDEX